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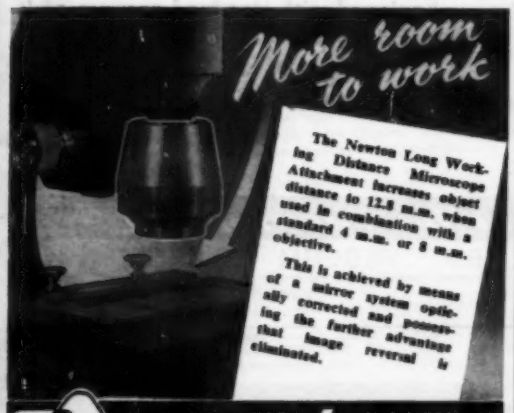
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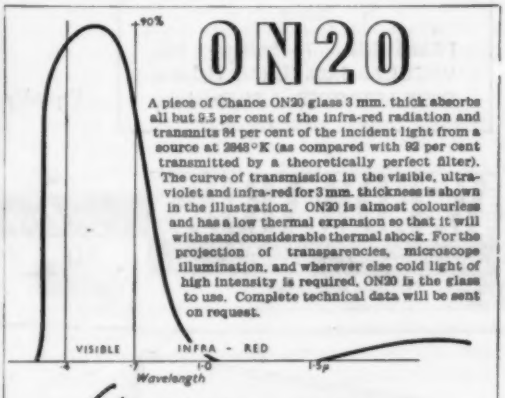


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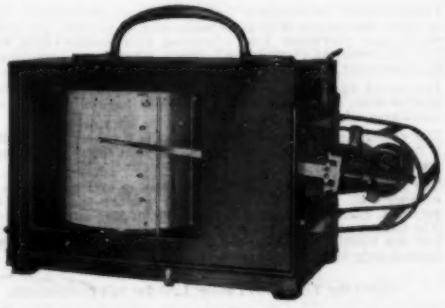

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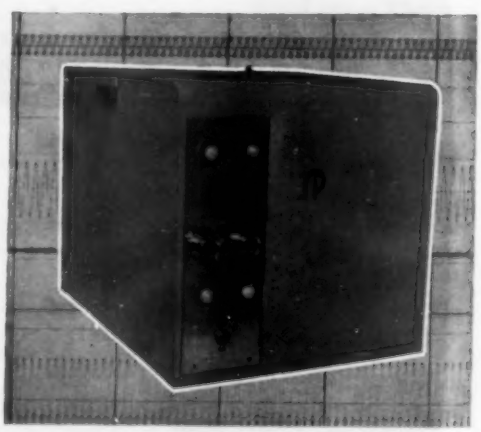

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## WORLD ORDER AND HUMAN FREEDOM

RATHER more than a year ago, Dr. K. T. Compton, as chairman of the Massachusetts Institute of Technology, gave an address to that Institute on the state of science at the mid-century. The address, published in the *Technology Review* of the Institute and since reprinted in the annual report of the Smithsonian Institution, in something more than title recalls the presidential address, "The Scientific World-picture of To-day", which General Smuts delivered to the British Association at its centenary meeting twenty years ago. Dr. Compton shares the confidence of Lewis Mumford as to the contribution which technological progress can make to the satisfaction of human needs, and he regards the rescue of world economy from the setback of the Second World War as an important task of science and technology to-day. He sees this, moreover, as a world task, and pleads for American men of science to assist in the rehabilitation of scientific institutions, of learning and of research generally.

From his survey of scientific achievements of the first half of the twentieth century, Dr. Compton draws five particular lessons. First, he stresses the co-operative character of scientific progress and its dependence on the stimulating interplay of ideas and the accumulation of facts and skills contributed by many workers. Secondly, he points to the unpredictable and uncontrollable origin of the new ideas and discoveries from which scientific progress results; and in this connexion he comments that the restriction of the flow of knowledge anywhere, or attempts to make it subservient to politics, ultimately stifles the birth and development of significant ideas.

The third lesson is that scientific discovery does not progress according to a preconceived plan, and is stifled if attempts are made to control the free initiative of the research workers or to limit the freedom of communication between them. The fourth lesson, that of the extraordinary effectiveness of team-work in producing results, is not inconsistent with the third, for such teams or groups provide the maximum opportunity for quick initiative and for stimulating interchange of ideas. A fifth lesson is the increasing extent to which a basic advance in theory or technique in one branch of science is likely to provide new concepts or new tools which can open up new frontiers for exploration and exploitation in other fields of science or art.

The confidence which characterizes Dr. Compton's survey, however, was not generally shared even when General Smuts drew his world picture, and even less is it universal to-day. General Smuts spoke of the serious lag which had developed between the rapid scientific advance and the relatively stationary ethical development. It is interesting to trace, in the Walker Trust Lectures on leadership delivered during the next few years, a general agreement that the idea of progress which marked much of the nineteenth century, and especially what is termed the Victorian age, is no longer generally accepted. To-day there is

even less disposition than a couple of decades ago, for all the wider appreciation of the value of the social sciences, to believe that man's knowledge and power over Nature automatically develop the wisdom and technique required for the knowledge and the conquest of human nature. Indeed, it has been remarked that one of the most distressing features of the present time is the widespread sense of impotence, and the consequent paralysis of individual action.

Clearly the advance of social science may have something to contribute here, though it may not of itself succeed in closing the gap to which General Smuts referred. Not all observers, admittedly, are agreed as to the dangers of this gap. Dr. R. Niebuhr, in his latest interpretation of history, for example, questions whether present catastrophes can be attributed to any such cultural lag or to the failure of man's social wisdom to keep pace with his technical advances. Nevertheless, the trend of his thought supports General Smuts's view on the necessity of linking up science with ethical values. One of the most potent causes of our present evils, Dr. Niebuhr insists, is the failure of men to bring their customs and institutions into conformity with new situations. In a period of rapid technical advance, the resultant maladjustments are a source of great confusion.

Dr. Niebuhr's main thesis is that we need, not merely a new and adequate social philosophy for the intense social cohesion of a new industrial age, but also an adequate faith. Lack of confidence in the future to-day may well be due to failure to consider adequately the moral and spiritual elements in civilization with which Dr. Niebuhr was especially concerned; but it may be due in part to failure to distinguish clearly the limits of human knowledge and human powers. The interest of Dr. Niebuhr's book for the scientific worker lies, indeed, chiefly in its pointer to some elements of weakness in the thought of Mumford and Mannheim, for example. Besides this, it provides reasons for a fresh attempt to think out the limits of the application of the scientific method in human affairs, the meaning of freedom, and the conditions of creative activity in the world to-day.

Such an attempt involves the consideration of the forms of government and social institutions which are required to bring under moral and social control the powers of creativeness and destructiveness which this age has both inherited and developed. That much is also implied in Dr. Compton's survey, with its emphasis on the over-riding importance of freedom in science; and a recent address on "Freedom in Science" broadcast by Prof. C. A. Coulson made even clearer the need for ensuring that our instruments of government make proper provision for such freedom. Prof. Coulson observed that, since patience, humility, tolerance, fairmindedness, integrity, co-operation and trust are the hallmarks of the scientific tradition, he has been forced to the conclusion that this tradition is ultimately based on, and derives its final sanction from, moral and ethical considerations which lie outside the field of what is popularly called science. A. N. Whitehead maintained that the inner conviction that the world is rational, and the confidence in one another that enables us to dispense with the verification of other people's claims, is a legacy coming to us from "the medieval insistence on the rationality of God". Prof. Coulson accordingly suggests that in a time of crisis like the present, which is marked by the breakdown of personal conviction among ordinary people, it is highly important that—in some senses and when properly understood—men of science are the custodians of many of the most precious values in our civilization.

From this aspect, Prof. Coulson agrees with Prof. Polanyi's view that the suppositions underlying our belief in science "co-extend with the entire spiritual foundations of man, and go to the very root of his social existence". But he discusses a possible danger to the freedom of science which might well arise from intoxication with power and an unmeasured faith in organization. This will have to be guarded against when the Science Centre in London now under consideration is established.

Nevertheless, it is well to remember that the established centres of freedom have almost all survived the past forty years, and that for all the post-war poverty of Europe the West as a whole is richer than ever. Dr. Compton's survey is indeed calculated to stimulate confidence in the future, as well as the fresh thought about the fundamental conditions of freedom in science—and elsewhere—and the organization required to serve those conditions. Once men of science grasp those conditions and seek to serve them, the dangers indicated by Prof. Coulson become remote. Positive action here is essential, for if the free world were content merely to be strong enough to deter aggression, much that matters most in Western civilization would stagnate or deteriorate. Somehow the Western world must recapture faith in itself and the spiritual values which it inherits, so that it will be able—through possibly a decade or more of acute mental and physical strain—not merely to maintain its existing freedoms, but also to adapt its ideas of freedom and the institutions which serve its social, intellectual, spiritual and material life to the needs of others. In this way, it will be enabled to advance and offer, both to its own people and to the less-developed communities of Africa and the East, standards, both material and moral, that no totalitarian system can provide. The reasons why the conditions of freedom generally, and the institutions in which they can best serve the advance of science and humanity, should be fully understood are well shown in a recent *Planning* broadsheet (issued by Political and Economic Planning) which reviews the prospects of the next decade. The processes and undercurrents of change there reviewed are likely to add to the scope and seriousness of the impacts of science on human societies, and to bring about a more scientific attitude to human problems. They may also further weaken both traditional and scientific materialism and lead to greater pressure for the application of science and technology and increased development of large-scale management and administration.

The necessity for creating a new sense of security and stability of a type capable of being reconciled with the rapid absorption of Western technical, economic and political ideas and techniques is likely,

in the view of *Planning*, to produce an intense competition of ideas. In its resiliency, its open-mindedness and its refusal to accept rigid creeds, the West has a considerable advantage in the scientific field, and potentially in the political and social organization; but Western ideas now for the first time face widespread and intelligently organized opposition. It is essential for the Western peoples to think out clearly the central ideas on which their civilization is based, and to examine how far they are derived from conditions not obtaining elsewhere, and how far they are likely to hold a universal appeal if properly presented.

In any such re-examination, the scientific worker must play his part, as Prof. Coulson's address makes plain. One important contribution to such thinking is to be found in the Dunning Trust lectures, which Prof. John Macmurray delivered at Queen's University, Ontario, in January 1949, and which have since been published under the title "Conditions of Freedom"*. Prof. Macmurray's analysis is valuable and should stimulate thought, though not all his conclusions are likely to find general acceptance. He seeks to distinguish the fundamental conditions of human freedom and the real obstacles to its achievement; but while he rightly points out that freedom is relative and that we are continually faced with the necessity of choosing between freedom and security, his deduction that strength and freedom are inconsistent scarcely seems to follow.

The two most important contributions which Prof. Macmurray brings to the discussion of freedom and its preservation in the world to-day are, first, his elucidation of this relativity of freedom, and second, his distinction between society and community. Although the full implications of both points are not brought out, at least he indicates the dynamic character of freedom, and that it cannot be preserved —or achieved—by force alone. Nevertheless, his exposition of the way freedom is conditioned may well stimulate some constructive thinking by those who are unable to accept his own conclusion that freedom cannot be defended by any physical means.

Western civilization in the modern period, Prof. Macmurray points out, has sought increase of freedom mainly along the technological road and by increasing power. In science and in other fields, the profits, as it were, have been ploughed back; knowledge has been pursued for its own sake and used for its own increase. An increase in our power, however, only increases our freedom if our demands remain relatively stable; doubling our resources while simultaneously trebling our demands upon them does not increase our freedom. This is why the vast increase in our resources in the past generation has been accompanied by a loss and not a gain in human freedom. Prof. Macmurray's reminder that both variables—the moral and the technological—must be considered, and that self-control is as imperative as the control of Nature if freedom is to be maintained, is essentially a paraphrase of General Smuts's remark on the necessity of discipline as well as freedom.

For such reasons Prof. Macmurray directs attention to alternative means to freedom. There is much evidence in the past five years that neither freedom nor the social welfare State is possible without self-discipline; but even more pertinent than his observations on this theme in considering the relativity of freedom is the truth that human freedom can be realized only as the freedom of each of us is relative to that of others; it depends upon co-operation. The essential conditions of freedom are social. Our freedom is relative to the conditions in which we live, and to the particular problems of human relationship which they set us.

Here Prof. Macmurray shows how the consideration of freedom inevitably leads to the consideration of problems of government. He believes that the conflicts of the contemporary world are symptoms of a change in the form of human society, and that a new chapter in the history of human development is opening. In the period of history immediately behind us, the struggle for freedom has been directed to the organization of the institutions of political democracy. These do not of themselves confer freedom upon those who live under them, and the task still remains, by means of these institutions, to secure for men essential justice, in a world in which the struggle for freedom of the individual has become one in the society of the whole of mankind and no longer just in a local and separate national group.

Had Prof. Macmurray pursued this question of the relations between law and justice and freedom, he might have avoided what to many will seem the fallacy of non-resistance. That, however, does not invalidate the important distinction he then draws between association and community, when he argues that essential justice can be achieved by co-operation not simply in a functional association, held together by a common purpose, but rather in the unity of a community which shares a common life and in which personality finds full expression. He believes that only in such a type of unity can personal freedom be achieved. He looks to a universal fellowship which would break down the barriers of nationalism, with all their political implications, leaving us free to draw such boundaries on the map as are most convenient for purposes of co-operative activity, and to arrange the co-ordination of these political units as far as is necessary.

It is on the steps by which such a world ideal is to be achieved that Prof. Macmurray is less convincing. If the moral conditions he outlines are observed, an effective world order will doubtless be achieved in our time and one in which human freedom is also secured. The problem is how the Western world can secure the observance of those conditions. Prof. Macmurray holds that the basic conditions of freedom lie outside the political field, and that freedom is the product of human fellowship and conditioned in the same way as friendship. He might perhaps agree with E. M. Young's suggestion that the aim of the universities of the West should be to re-formulate in to-day's new context the liberal conception of public

* Conditions of Freedom: being the Second Lectures of the Chancellor Dunning Trust, delivered at Queen's University, Kingston, Ontario, 1949. By Prof. John Macmurray. Pp. 106. (London: Faber and Faber, Ltd., 1950.) 6s. net.

opinion by the gradual building up of such a body of liberal knowledge, humane knowledge—if you like, of social knowledge—as will serve to direct, to animate and to control those illimitable powers which science has put into the hands of mankind—and its rulers.

That, however, must be a long-term process, and one in which men of science generally—and not social scientists only—have an important part to play, as they have also in the determined effort which the free Western world must make, within and without the political field, to prove its friendship and goodwill to the rest of the world. Open-mindedness, reliance on example and persuasion rather than on authority—these are ways in which science has grown in the past and in which the Western world, without discarding its strength, could speak across frontiers in terms of friendship to the whole world. It is one thing, however, to spare no effort to that end which does not endanger the heritage of freedom and order which the West enjoys. It is another to throw down the ramparts in the present divided world, and when Prof. Macmurray calls for this he overlooks the truth stated so clearly by Lord Bryce in "Modern Democracies": "Governments have ruled by force, and few have been able to live without moral sanctions, or to make their subjects believe that these sanctions consecrated them, but no free government has ever yet so lived and thriven, for it is by a reverence for the Powers Unseen and Eternal which impose these sanctions, that the powers of evil have been, however imperfectly, kept at bay and the fabric of society held together".

World order and human freedom to-day depend, as when Bryce wrote in 1921, on moral and spiritual issues, and on the ability of the Western world to recapture its confidence and a vision and faith which will transform passive defence into an inspired and resolute effort to establish freedom for all men in every field of human endeavour, including science, in a world united because friendship and confidence have displaced mistrust and fear.

---

## G. D. BIRKHOFF'S COLLECTED PAPERS

### Collected Mathematical Papers

By George David Birkhoff. Vol. 1. Pp. lvii+754. Vol. 2. Pp. vii+983. Vol. 3. Pp. vii+897. (New York: American Mathematical Society, 1950.) 3 vols., 18 dollars.

ALL mathematicians will be grateful to the American Mathematical Society for publishing the collected works of the late Prof. G. D. Birkhoff, one of the most distinguished of its former presidents. The three volumes include not only his original research papers, but also a number of addresses, reviews, obituary notices, committee reports, etc., many of which are of high interest and value, and which it would be difficult to obtain elsewhere.

As the name would indicate, Birkhoff's family was originally Dutch, but it has long been settled in the United States; he was born at Overisal, Michigan, in 1884, and died at Cambridge, Mass., in 1944. In his student days, the American schools of highest reputation in mathematics were those at Harvard and Chicago. Birkhoff studied first at the latter, then graduated at the former, and finally returned to Chicago in 1905 for his doctorate, which he took with a thesis on linear differential equations. His interest in this subject had originated when he was attending Bocher's lectures at Harvard; during the two last years at Chicago, it was continually in his mind, and he devised original methods for dealing with it, permeated by the group-theoretic point of view, and making considerable use of the matrix calculus. His most striking achievements were a satisfactory theory of the irregular singular point, and a number of theorems on the reduction of equations with given types of singularity to canonical forms.

In 1909, Birkhoff was appointed assistant professor of mathematics at Princeton, and it was here, in 1911, that he wrote a memoir on linear difference equations which did much to bring him into prominence; the *Jahrbuch über die Fortschritte der Mathematik* devoted more than two pages to a notice of it, a rare honour for a young and unknown author. To this domain he brought the new ideas that had proved so successful in his work on differential equations; and he was able to show that for a difference equation of any order there are two matrix solutions, the elements of which are one-valued and regular, save at poles in the finite part of the plane, and which are defined by their asymptotic properties with respect to the half-planes unbounded to the right and left respectively; their matrix quotient must be a matrix of periodic functions of period unity. He showed, moreover, how to construct a system of difference equations which have a prescribed behaviour with respect to their singularities.

The work of 1911 on linear difference equations was followed two years afterwards by a memoir, which attracted almost as much attention, on Poincaré's last geometric theorem. The theorem is this: if a ring-shaped region bounded by two concentric circles is transformed into itself by a transformation which is one-to-one, continuous and direct, and which conserves areas, and if the transformation displaces points on one of the bounding circles in the clockwise sense, and on the other bounding circle in the counter-clockwise sense, then in the interior of the region there will be two points transformed into themselves. This was conjectured in his last paper (1912) by Poincaré, who showed that it would lead to concluding the existence of infinitely many periodic motions in the problem of three bodies and similar problems—an interesting inter-relation of topology and dynamics. He expressed the hope that some younger men would take up the matter. Only a few months later, Birkhoff did so and gave a complete and elegant proof.

Birkhoff was deeply influenced by Poincaré's great treatise, "Les méthodes nouvelles de la Mécanique céleste", which had appeared in 1892–99; and much of his most important work related to general dynamics and the theory of orbits. His first notable memoir in this field, published in 1917, developed simple and general criteria for the existence of periodic and recurrent orbits, and of orbits asymptotic to them.

Closely connected with these dynamical researches was Birkhoff's work on the ergodic theory. The name ergodic was given more than seventy years ago by Boltzmann to those mechanical systems which have

the property that each particular motion, when continued indefinitely, passes through every configuration and state of motion of the system which is compatible with the value of the total energy. The assumption that the systems considered in the kinetic theory of gases are ergodic was made by Maxwell and Boltzmann. Birkhoff in 1931 published a fundamental result which he called the "ergodic theorem", and which may be stated as follows. For any dynamical system which satisfies certain conditions (which, in fact, are generally satisfied by the systems occurring in theoretical physics), there is a definite 'time probability' that any moving point, except those of a set of measure zero, will be in an assigned region $v$; that is, if $t$ denotes the total interval of time elapsed from a fixed instant, and $\bar{t}$ the sum of the portions of this interval during which the point of the trajectory lies in $v$, then $(\bar{t}/t)$ tends to a definite limit. This theorem, which Birkhoff proved by aid of an essentially new algorithm, goes far towards supplying a rigorous foundation for statistical mechanics.

In later life, Birkhoff became interested in the discovery of mathematical relations concerned with æsthetics, and in a new theory of gravitation. His miscellaneous papers range over an immense variety of topics; and the long list of doctorate theses directed by him, containing many names of men who are now in the front rank, shows in a striking fashion the great part that he played in forming the present generation of American mathematicians.

EDMUND T. WHITTAKER

## MEGALITHS OF ENGLAND AND WALES

### The Prehistoric Chamber Tombs of England and Wales

By Dr. Glyn E. Daniel. Pp. xiv+256+16 plates. (Cambridge: At the University Press, 1950.) 31*s.* 6*d.* net.

THE numerous standing stones, dolmens, barrows and other forms of megaliths which can be seen in various parts of Britain have always been objects of great interest not only to the prehistorian, but also to everyone who either lives in a district where they occur or who comes across them when travelling or on holiday. Dr. Glyn E. Daniel has put us all in his debt by preparing this detailed and comprehensive account of the chamber tombs, and where they are found and how they can be classified. The work is fully illustrated with diagrams, maps and photographs, and contains a wealth of information. Anyone, whether student or interested amateur, who proposes to visit an area where these constructions occur would do well to take Dr. Daniel's book with him: he will find it invaluable.

The opening chapter is concerned with the distribution of the monuments, and the geographical conditions of the period. Evidence is marshalled to show that we must consider their distribution "against the background of a Britain with a coastline extending to the present 5- or even 10-fathom line, and a heavily forested countryside". An account of the methods of construction follows, and then a chapter which deals with the various different forms of tomb which are found; because all chamber-tombs are by no means the same in plan nor have they all the same origin. An interesting chapter on ritual and symbolism comes next. Why is there a burial at Notgrove and again at Bryn Celli Ddee, inaccessible from the passages, which themselves contain numerous bones? What is the meaning of the pillar at the latter site which upholds nothing? Can we get any evidence as to what were the ceremonies practised when these monuments were in use? What is the interpretation of the engravings occasionally found on the walls within the tombs? Not all these queries can be answered; much must be guesswork, but Dr. Daniel at any rate tackles the problems. The stone at Bryn Celli Ddee, buried in the central pit and not to be reached by the passage, is covered with zigzag markings which closely resemble those on a pointed headstone in a barrow in north Spain. It also appears to have Irish connexions. Again, the interlocked concentric circles at Sess Kilgreen in Co. Tyrone—rather than any found at Loch Crew as suggested by Dr. Daniel—are very similar to the carvings on the walls at Gavr'inis in the Morbihan, Brittany; but any art on the megaliths in this latter country is rare, and even in Ireland there is only the one group that is much decorated. A chapter on the archæological finds associated with the monuments follows. I always have a sneaking feeling that in some cases, where objects of late date occur in association with the constructions, the association is real and not fortuitous—that the megaliths were actually of late date though belonging to the more ancient culture which had continued to survive. It is just when we are dealing with death that man is most conservative and that ancient traditional practices tend to continue even after their parent culture has in other respects undergone change. Finally, there is a chapter on origins and dating, and an excellent inventory of sites which forms Part 2 of the book and which will be especially useful both for reference and as a "Baedeker" for the monuments.

Dr. Daniel is a scholar, and his "Prehistoric Chamber Tombs of England and Wales" is a notable contribution to the literature of his subject.

M. C. BURKITT

## TEXT-BOOK OF PLANT PHYSIOLOGY

### An Introduction to Plant Physiology

By Otis F. Curtis and Prof. Daniel G. Clark. (McGraw-Hill Publications in the Botanical Sciences.) Pp. xiii+752. (London: McGraw-Hill Publishing Co., Ltd., 1950.) 55*s.* 6*d.*

IT now seems to be pretty generally agreed that plant physiology covers an uncomfortably wide field to be dealt with, even at an intermediate level, by a single author, and it is usual to find more than one name on the title page of a text-book, or numerous acknowledgments of help received. Reviewing has not yet been put similarly into commission, and it is perhaps inevitable that any attempt at a critical evaluation should be biased by the reviewer's own competencies and predilections. It therefore seems more profitable to speak of the general approach of Profs. Curtis and Clark to their subject rather than to dissect particular chapters of their book.

It is immediately obvious that the authors have spent much thought and care on their didactic method; and it is not without reason that they have made their dedication to the generations of their students. It is easy to believe that for them the

teaching of plant physiology has indeed been both "a recreation and a challenge". Conventional means, such as the provision of questions at the end of each chapter, are freely used; but it is important that the questions asked are not such as may be directly answered by turning back to the preceding text. Some thought and arrangement of ideas and facts is always called for, and it is perhaps fortunate that discussions of some of the more debatable problems are provided in an appendix. A less usual and very interesting attempt to help the student is made in a second appendix, in which are discussed some of the commoner pitfalls besetting the beginner in the interpretation of data and biological reasoning.

As their aim is at an intermediate standard, the authors have decided to touch only lightly on topics requiring more than the most elementary mathematical, chemical or physical background. Descriptive growth and transport phenomena, therefore, come in for much fuller treatment than metabolism, and photosynthesis is treated largely, though by no means exclusively, from an ecological point of view. The authors claim to consider that a critical handling of a few topics is a more effective training in scientific method than a discursive treatment of many. This attitude, long-familiar and well-tested in the 'type' system of elementary biology, is a sound basis for teaching; but it is not very clear how the present book exemplifies it. Considering its aims, its treatment must be considered as extensive and occasionally even ambulatory. It is, nevertheless, easy reading and makes a welcome and most interesting addition to the limited number of existing plant-physiology texts.

W. O. James

## SLIDING SURFACES

### The Friction and Lubrication of Solids

By F. P. Bowden and D. Tabor. (International Series of Monographs on Physics.) Pp. xii+337+32 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1950.) 35*s*. net.

THERE can be no doubt about the importance of the subject to which this book brings such a valuable contribution. But for the surprising ease with which smooth surfaces can be made to slide over each other, even when heavily pressed together, our modern civilization would be impossible.

The use of oils and greases to reduce friction and suppress wear of sliding surfaces is an ancient practice which, with the coming of the machine age, has been developed with remarkable success by the engineer on an empirical basis of the trial-and-error approach to each problem as it arises.

Although Amontons's law, according to which friction is proportional to the loading of the bearing surfaces irrespective of their areas, was the first broad generalization on sliding and was framed so long ago as the end of the seventeenth century, its fundamental significance has only recently been appreciated. On the other hand, when, nearly two hundred years later, Osborne Reynolds propounded his hydrodynamic theory of lubrication, this attracted and held the attention of the engineer and thus dominated for many years the design of the sliding element. Under the severe conditions of modern engineering practice, however, Reynolds's thick oil film cannot always be maintained; it is often reduced to molecular dimensions and may, indeed, be broken through, so that here and there the sliding surfaces come into direct contact. This has so greatly increased the complexity of the problems associated with mechanical wear and lubrication that the empirical approach, even if guided by the hydrodynamic theory, is no longer adequate, and the implications of Amontons's law in their bearing on these changed conditions have become of enormous practical importance. The simulated model experiment or the full-scale engine trial with its many hidden and uncontrollable variables may help, at a price, to deal with the special case, but cannot take the place of the broad generalization resulting from the well-conceived scientific experiment.

The need for a scientific study of lubrication and wear seems to have been recognized more clearly in Great Britain than elsewhere, and F. P. Bowden and D. Tabor's imposing monograph is a record of the fine work done by the Cambridge research group on the physics and chemistry of rubbing solids, which for the past fifteen years has been carrying on the traditions of the earlier work of Beilby and Hardy.

Even the simplest form of sliding element consists of nine components, and most of this book is devoted to a study of four of these, namely, the metal bearing surfaces and their respective adsorbed boundary layers of lubricant. The authors have made a close and stimulating study of intermetallic welding between sliding surfaces and its consequences, and this, no doubt, has influenced them in attributing friction mainly to this source. My own view is that a sliding system in which the intermetallic component of friction makes a major contribution to the resistance to sliding is unsatisfactory. Owing to surface work-hardening during their formation, welds are more prone to shear in the body of the metal than in the plane of sliding, and th s must lead to excessive friction and severe mechanical wear. Thus it seems to me that, apart from the shearing boundary layers, the main source of friction is that due to the rubbing oxide (or sulphide, etc.) layers which are, fortunately, inevitably present on the metallic bearing surfaces. It is only when these are broken down that the bearing may be said to fail in the sense that intermetallic friction ensues. The resistance of the oxide layer to rupture is more a matter of the rigidity of the supporting metal in the regions of localized stress than a property inherent in the layer itself. I imagine that this difference of opinion is mainly one of point of view; it is only recently that the Cambridge school has begun to make use of the penetrating eye of the electron-diffraction camera. I am sure that the authors would agree with me that, but for the thin oxide film of little more than molecular thickness and its self-healing capacities, modern sliding practice would not be possible.

This is not a comprehensive text-book, nor, as we are told in the preface, is it meant to be. It deals almost wholly with the original work of the authors and their collaborators and is therefore a first-hand story of well-planned experiments and their results. This, by itself, lifts it far above the general level of other books on the subject. The engineer and the instrument maker will do well to have this book at hand. The physicist and chemist will enjoy an inspiring and well-illustrated story which tells of experimental adventure and discovery, and points the way to yet other avenues for future exploration.

G. I. Finch

## Introduction to Chemical Engineering Thermodynamics

By Prof. J. M. Smith. (McGraw-Hill Chemical Engineering Series.) Pp. x+386. (New York and London: McGraw-Hill Book Co., Inc., 1949.) 34*s*.

THIS is primarily a book for senior undergraduate students with a knowledge of physics, physical chemistry and elementary calculus; but many older members of the profession will find much that is of interest and value among its pages. It explains with care and at some length, sometimes perhaps at too great length, the fundamental principles of thermodynamics and the way in which they are applied. Lest it be thought that the title "Chemical Engineering Thermodynamics" refers to some new branch of the subject, the author indicates in the preface that all that is meant is that those branches of thermodynamics which are of special interest to chemical engineers are more fully dealt with and that examples are chosen from cases which are met with in chemical engineering practice. A valuable feature is the large number of worked-out chemical engineering problems which illustrate, better than any explanation, how the many formulæ can be used in their solution.

The main subjects dealt with are: the First Law and its application to flow processes, pressure–volume–temperature relationships for ideal and real gases, thermochemistry, temperature scales, entropy, the thermodynamic properties of fluids, nozzles, the production of work from heat, compressors and refrigerators, phase equilibria and reaction equilibria.

Of the paper and printing, including many complicated formulæ and diagrams, it is perhaps sufficient to say that they are fully up to the high standard of this series of publications. The volume should find a place in the library of every chemical engineer. H. E. WATSON

## A Concise History of Mathematics

By Prof. Dirk J. Struik. Vol. 1: The Beginnings—The Beginnings in Western Europe. Pp. xviii+124. Vol. 2: The Seventeenth Century—The Nineteenth Century. Pp. vi+125–300. (New York: Dover Publications, Inc., 1948.) 2 vols., 3 dollars.

THE author embarks on an arduous mission when he sets himself the task of compiling a concise history of mathematics which not only presents the leading ideas in the development of mathematical thought, from the earliest deductions of prehistory until the beginning of the present century—and refers to all the outstanding mathematicians and many of the lesser men as it does so—but also indicates the social settings in which the subject has developed. Dr. D. J. Struik has done more than this. In addition to fulfilling this task, he has supplied a large number of references and has found space within his two small volumes, which contain only 299 pages of text matter between them, to incorporate drawings, portraits and reproductions of specimen pages from original documents.

After a short chapter on the development of the number concept, the first volume discusses the facts which are known about the early mathematical achievements associated with Egypt, Babylonia, China, India and Arabia. A full account is given of Greek influence on mathematical ideas, and the volume concludes with a chapter on the early progress of mathematics in Western Europe, which led to the discovery of logarithms at the beginning of the seventeenth century. The second volume continues the story by devoting each of its three chapters to a separate century.

Recently discovered historical material, which cannot readily be found in larger standard works, may be found in each volume. The author's ability as a first-class historian as well as an able mathematician has enabled him to produce a work which is unquestionably one of the best of the many short accounts of the history of the subject that have been produced in recent years. The use of variations of proper names that differ from those usually accepted at the present day—such as Cardano and Neper for Cardan and Napier—is presumably based on a considered assessment of available data. The reviewer admits the difficulties involved when contemporary documents vary and the owner is inconsistent in his own references to himself, but he feels that a strong case could be presented for accepting the normal orthography of the present day in all cases where historical inquiry tends to become a matter of personal choice.

## Information Services

Their Organisation and Administration. By R. L. Collison. Pp. viii+81. (London: James Clarke and Co., Ltd., 1950.) 6*s*. net.

THE necessity for speed, probably the most significant obligation that this present century has imposed upon research, is more than anything else responsible for the growth of a systematic and scientific approach to information work. As the head of the Westminster Central Reference Library, Mr. R. L. Collison is in as good a position as anyone to grasp the full implications of this fact, and the note of urgency, strengthened by insistence on the need for quality, pervades his slight but eminently practical introduction to the problems of organizing an efficient information service.

As methodical as the service which he envisages, Mr. Collison mobilizes his staff and equipment, books and records with a facility that may leave the novice unconvinced of the complexity of his job. Yet he has laid a foundation on which a beginner may safely build—and it is, unfortunately, on the raw beginner that this, as yet largely unrecognized, service so often falls. With notable exceptions, British industry has yet to learn that information services have a part to play in national recovery out of all proportion to the cost of running them. Mr. Collison will not convert industry. But he should save the converted time and trouble—and that twentieth-century consumer of energies, frustration.

## The Spider

By John Crompton. Pp. 254. (London and Glasgow: Wm. Collins, Sons and Co., Ltd., 1950.) 10*s*. 6*d*. net.

MR. J. CROMPTON does not claim a close acquaintance with spiders themselves, but he has read the books of McCook, Fabre and Bristowe. From these and others, always with due acknowledgment, he has compiled a second-hand account of spiders' habits, in a wholly anthropomorphic vein; for example, "The proprietress of the web gives him a calm scrutiny and two thoughts occur to her". With the addition of much irrelevant anecdote, this book conveys a reasonably accurate picture of the life of the spider, marred only by uncritical acceptance by the author of all that his chosen authorities have written. It is, moreover, written in a facetious style which some readers will find intolerable; it may, however, persuade some of them to study spiders, not books, more carefully.

T. H. SAVORY

# STRUCTURE OF SHOWER CLOUDS

By F. H. LUDLAM*

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IN a famous paper published in 1935, Bergeron[1] suggested that almost all 'real raindrops' (that is, drops of diameter greater than 0·5 mm.) originate as ice crystals in clouds of supercooled droplets. This view was vigorously supported and developed by Findeisen, who emphasized that once a crystal (growing rapidly in the high ice-supersaturation existing in a supercooled cloud) has become considerably larger than the droplets, its growth may be greatly accelerated by coagulation with them following collisions due to its greater speed of fall. Similarly, collisions might be expected to lead to the continued growth of the larger of the droplets in wholly liquid clouds; but the process has been regarded as a slow and inefficient mechanism for the release of precipitation, capable of producing only drizzle drops (of diameter less than 0·5 mm.). Nevertheless, when Findeisen calculated the diameter of drops which would thus be expected to fall from a typical layer cloud, he found a value of 0·8 mm. for a cloud 1,000 m. thick, a result which he rejected as contrary to experience. Recently, observations have accumulated which show that, at least in tropical regions, heavy rains may fall from clouds which are wholly below the level of the 0° C. isotherm. Equally deep rain-clouds in temperate climates would commonly reach heights where the temperature is below −20° C., so that their tops would certainly contain ice crystals; it does not follow, however, that their presence is essential to the production of rain.

A further examination has now been made of the growth of droplets and of crystals under the conditions which occur in convective clouds (cumulus). It is essential to consider how these conditions are controlled by the large-scale physics of the clouds. Two factors of the greatest importance in the development of shower rain are the strength of the updraught and the concentration of liquid water within the cloud. The dimensions of the cloud are also important: small clouds have weak updraughts (of about 1 m./sec.), and their liquid-water content may be reduced by mixing with air from the environment; in large clouds, on the other hand, there are often strong updraughts (exceeding 5 m./sec.), and it is believed that in their interiors the liquid-water content approximates closely to that calculated by assuming the air to rise from the cloud base, carrying the condensate and cooling at the saturated adiabatic rate with respect to liquid water. We then find that the rate of rise of individual cumulus tops is simply related to the liquid-water content and the difference between the temperatures inside and outside the cloud. Detailed observation further shows that isolated cumulus are assemblages of small air masses which rise through the body of the cloud to the upper surface, and which are then replaced by others, sinking aside and evaporating while mixing into the environment. The life of individual cloud masses is thus less than the life of the cloud as a recognizable whole, and seems rarely to exceed about thirty minutes unless they are transformed into ice clouds at high levels, when their decay may extend over several hours. It would thus at first appear that the life of individual cloud particles is equally limited; but here it must be recognized that when a particle has grown to a diameter of about 300 $\mu$ it will have sunk relative to the air some two or three hundred metres, and can survive a fall of similar magnitude through unsaturated air. There is thus a high probability that such a particle outlives the much smaller droplets among which it arose, sinking back into the bulk of the cloud and continuing its growth into a precipitation element, while they are carried to the walls and evaporated. The condition for the development of precipitation within cumulus is thus that particles of at least this size shall be grown during the time taken for cloud air to rise from the base to the top. If the entire cloud is small, its own life may be little more, so that the particles are still prevented from growing into raindrops; but if the cloud is large a shower is almost certain to develop, although a wind shear often interferes both by reducing the life of the cloud and by carrying the upper parts away from the bulk of the cloud.

The equations from which size-time and size-height trajectories of a droplet growing by collisions may be found by numerical integration are:

$$\frac{dr}{dt} = \tfrac{1}{4} E v_{\mathrm{rel}} m, \qquad \frac{dz}{dt} = U - v,$$

where $r$ is the radius of the droplet, $v_{\mathrm{rel}}$ and $v$ are its velocities relative to the smaller droplets and to the air respectively, $m$ is the concentration of liquid water in the form of the smaller droplets, $U$ is the speed of the updraught, and $E$ is the fraction of the droplets in the path of the collector with which it collides. Langmuir[2] has obtained formulæ for $E$, assuming the collecting droplet is large compared with those being overtaken; the formulæ suggest that no collisions occur at all unless the ratio of the sizes exceeds a critical value, but they are not applicable to small droplets of comparable sizes. However, this is not a critical difficulty in considering the development of rain in *convective* clouds, for it may be calculated that unless a droplet begins its life with a radius of more than about 20 $\mu$, in a typical population the average size of which increases from about 5 $\mu$ to 10 $\mu$, then even with the highest possible values of $E$ its growth is extremely slow, simply because of the small relative speeds of fall. The growth of droplets of radius less than 30 $\mu$ in radius has therefore not yet been considered; on the other hand, if Langmuir's formulæ for $E$ are used to estimate the growth of droplets having radii of 30–80 $\mu$ near the cloud base, it appears that: their growth into raindrops proceeds relatively rapidly, and that in tropical climates, providing the cloud is at least some 1,500–2,000 m. deep, they can develop into raindrops, which could therefore fall from a wholly liquid cloud. In temperate latitudes, the growth of droplets is somewhat less rapid, because of the lower water content of the clouds; and since here the 0° C. isotherm is not often more than 2,000 m. above the cloud base in showery weather, showers are unlikely to fall in these regions from clouds not rising above the 0° C. isotherm.

The introduction of droplets of radius 30 $\mu$ or more into the cloud base appears to demand the presence of large hygroscopic nuclei. Recently, Woodcock and Gifford[3] have sampled salt nuclei over the sea near Bermuda and Florida at heights

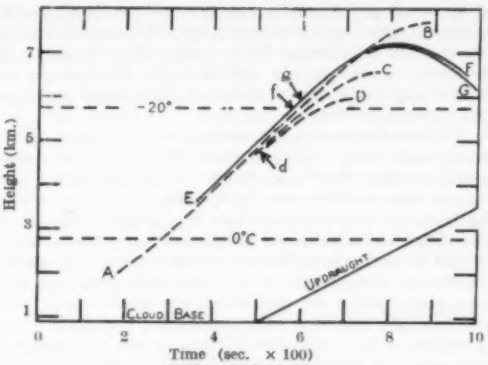
* Working with a Leverhulme Research Grant while on leave from the Meteorological Office, London.

up to 1,000 m., and have found small concentrations of nuclei of the necessary size: the largest, in concentrations of about 1/litre, have radii of 80 $\mu$ or more at 100 per cent relative humidity, and are therefore capable of introducing droplets of at least this size into the clouds of these regions. It must be emphasized that one such droplet among $10^8$ cloud droplets (or even more, if breaking of raindrops occurs in the cloud) is a sufficient concentration for the efficient production of rain. It may be assumed that these large nuclei exist in most maritime air masses, especially when spray is formed and convection is active. Well inland, away from their sources, they must be expected to disappear; convective clouds in the interior of continents therefore probably have a higher degree of colloidal stability than clouds formed over and near the oceans, and it may be that for showers to occur in continental air masses (where, of course, clouds have higher bases), the clouds need to rise well above the 0° C. isotherm, the rain developing from the ice phase—although one may wonder if here dust or large smoke particles from burning vegetation could not equally well serve to start the collision process.

It has next to be considered whether the appearance of ice crystals in the upper parts of the shower clouds of extra-tropical regions is really responsible for the production of rain. As the weather becomes colder, the level of the 0° C. isotherm descends, so that crystals are introduced into the cloud at successively earlier stages, until finally the whole cloud is supercooled and they are introduced at the cloud base at the same time as any large nucleus-droplets. It is therefore important to examine their relative rates of growth. This has been done on the basis of suitable assumptions concerning the shape and density of ice particles originating at various temperatures below about −5° C. At first they grow solely by the deposition of vapour, which in the supercooled cloud is considerably supersaturated with respect to ice, and in most clouds they have within a minute or two acquired a size and relative speed of fall such that coagulation with droplets soon gains predominating importance. An exception, now being investigated by R. Wexler, occurs in very cold clouds (base temperatures below 0° C.) with weak updraughts and small liquid-water content, where dendritic growth of many crystals sets in before appreciable coagulation begins, so that the ice particles develop into snow crystals rather than the coagulation elements recognized as 'graupel' or hail. The development of dendritic crystals is thought to be accompanied by the multiplication of ice nuclei due to the 'splintering' process, so that the number of snow crystals quickly increases to the point where the supercooled droplets disappear, coagulation into snow-flakes begins, and a snow shower is produced. This typically occurs during the decay of cold-weather shower clouds.

In all but these cold clouds, it appears that if the necessary small concentrations of large droplets occur at the cloud base, then the bulk of the precipitation may be produced by their growth rather than by the growth of ice crystals.

This conclusion is supported by the observation that *droplet-clouds* survive for a time at the summits of many of those shower clouds of maritime air masses which do not reach far above the 0° C. isotherm. Even in their upper parts, such clouds develop fibrous streaks of precipitation, commonly but wrongly accepted as evidence of glaciation, since in these instances they are almost certainly composed




GROWTH OF PRECIPITATION ELEMENTS

In a cloud having a base at 900 mb., 10° C., and containing $10^8$ uniform droplets per gm. of air in an updraught increasing from 5 m./sec. at the base to 10 m./sec. above 3½ km., rare droplets of radii 30, 40 and 50 $\mu$ at the point *A* reach a radius of 1 mm. at *B*, *C* and *D* respectively. Rare ice particles originating on efficient ice nuclei in the same air when it reaches *E*, where the temperature is −5° C., are assumed to grow into hailstones of density 0·3 (which at *F* become wet with a radius of 1·0 cm.) or of density 0·6 (which at *G* become wet with a radius of 0·6 cm.). At *f*, *g*, *d* these ice particles and the droplet of initial radius 50 $\mu$ respectively reach radii of 150 $\mu$

of raindrops, as is occasionally proved by a rainbow extending through them to the cloud tops. Schwerdtfeger[4] found that in summer near lat. 60° N., long. 13° W., the most frequently observed temperature near the level of the summit of shower clouds was −3° C., which again suggests that ice crystals could not have made any significant contribution to the rain. In a verbal communication E. G. Bowen (Commonwealth Scientific and Industrial Research Organization, Sydney), who has also deduced the importance of droplet growth, reports radar observations of shower clouds with similar temperatures at summit-level which conclusively show that rain developed without the intervention of ice crystals.

Even in clouds which contain powerful updraughts and quickly tower to levels where the temperature is very low, the bulk of the precipitation may be produced by droplet growth.

This is illustrated by the accompanying graph, which describes the growth of large droplets and the first-formed crystals in a cloud having a base at 900 mb. and 10° C., and containing an updraught which increases from 5 m./sec. at the base to 10 m./sec. at levels above 3½ km. Below 4,700 m. in this cloud there are no particles of radius greater than 150 $\mu$, and so if its growth were interrupted before this height is reached then the development of precipitation is unlikely. Beyond this stage, however, precipitation elements are rapidly grown; within five minutes the large droplets attain radii greater than 1 mm., and soon afterwards the ice crystals grown upon nuclei active at −5° C. have become hailstones with radii of about 1 cm. The surfaces of these hailstones become wet at air temperatures below −20° C.: they are then picking up more supercooled water than can be frozen, it being impossible to dispose of the latent heat of fusion to the environment sufficiently quickly. The further growth and interaction of the liquid and frozen precipitation elements is complicated; but it can readily be appreciated that the drops grow and accumulate rapidly in the upper levels of the cloud, since on reaching a radius of about 3 mm. and a speed of fall about equal to the speed of the updraught they become distorted to the point

of shattering. A chain reaction of raindrop multiplication thus begins in which the total concentration of rain-water increases by a factor of perhaps 15 or 20 every three minutes, which is the time taken for a raindrop fragment of radius 1 mm. itself to reach the disruption size.

If then the initial concentration of large droplets were only 1/m.³, unrestricted growth at this rate could increase the liquid-water content in some upper part of the cloud to more than 15 gm./m.³ within about 12 minutes of the time when the largest particle in the cloud had a radius of 150 $\mu$, and this concentration would certainly be sufficient to destroy the updraught. However, this stage is not reached quite so precipitately, since as the raindrops accumulate they increasingly interfere with each other's growth. It is possible to take account of this in the calculations, to adjust the speed of the updraught to the increasing concentration of liquid water, and to include the effect of the development of the ice phase; but without going to these lengths it is evident that the occurrence of a few large droplets near the cloud base is of great importance. The precipitation may develop largely from them rather than from the ice phase, appearing as rain with a proportion of hail; the development of raindrops indeed severely restricts the growth of most of the ice particles by removing water from the air rising to feed them, so that the crystals grow into snowflakes, or remain very small and are left at the cloud top in vast numbers to form the fibrous anvil-cloud so characteristic of the cumulo-nimbus. It must be remarked that the occurrence of rain in the supercooled part of a shower cloud is no proof that it does not develop from ice particles, since the shedding of surplus water from wet hailstones could also initiate a chain reaction of raindrop multiplication in this part of the cloud.

All these effects will be examined quantitatively in a number of cloud models in which the initial updraught speed, the temperature of the summit-level and base, the size of the large droplets introduced at the base, and the concentration and efficiency of the ice nuclei are all varied. First, however, the relevant equations are being prepared for integration by an automatic calculating machine. It is hoped that the EDSAC in the Cambridge University Mathematical Laboratory will be used.

It already appears that the methods of artificial seeding with ice nuclei of cumulus the tops of which are barely supercooled are unlikely to induce rain formation, except perhaps by the accidental introduction of large droplets, and that the most generally profitable procedure (equally applicable to clouds not reaching above the 0° C. isotherm) might be the spraying of droplets ($r > 30\ \mu$) or large hygroscopic nuclei into the cloud base. At least in maritime air masses, however, the absence of showers from apparently suitable clouds is often likely to be due to unfavourable macro-physical circumstances rather than to a remediable lack of appropriate hygroscopic nuclei or ice nuclei. Consideration is now being given to the problem of inducing showers in the light of the results quoted above, which will be discussed in more detail in future papers. It is hoped also to examine whether the separation of thunderstorm charges may be due to large-scale drop-breaking in cumulo-nimbus, since the conditions under which this may occur can be calculated.


[1] Bergeron, T., *Proc.-Verb. de l'U.G.G.I.*, Lisbonne, 1933 (1935).
[2] Langmuir, I., *J. Met.*, **5**, 175 (1948).
[3] Woodcock, A. H., and Gifford, M., *J. Mar. Res.*, **8**, 177 (1949).
[4] Schwerdtfeger, W., *Met. Rundschau*, **1**, 453 (1948).


# NUCLEAR AND CYTOPLASMIC DETERMINANTS OF HEREDITARY CHARACTERS IN *PARAMECIUM AURELIA*


By Dr. G. H. BEALE

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*PARAMECIUM AURELIA* is an exceptionally suitable organism for the study of the role of the cytoplasm in heredity. At conjugation, nuclei are exchanged between partners, but the two cytoplasms do not normally mix. Consequently, if animals differing in both cytoplasm and nuclei conjugate, their progeny will come to contain identical nuclei but diverse cytoplasms. Exceptionally, however, exchange of cytoplasm at conjugation does occur, and can be controlled. It is therefore possible to obtain at will various combinations of different nuclei and cytoplasms, and to study the roles of both.

Extensive results have now been accumulated by Sonneborn[1] and his colleagues on the genetics of two groups of characters in *Paramecium aurelia*. These are (1) the antigen and (2) the 'killer' character. Superficially the two groups seemed to be determined by similar genetic mechanisms, since both antigens and killers were found to require a favourable combination of nuclear and cytoplasmic determinants. Yet it is now becoming more and more clear that there are profound differences in the causation of the two kinds of character. Furthermore, a comparison of the two mechanisms turns out to be valuable for an understanding of certain central problems of biology.

## The Antigen System

The antigens will be considered first. If a concentrated brei of paramecia is injected into a rabbit, the latter's serum is soon found to contain antibodies. These antibodies react characteristically with substances on the surface of paramecia of the same kind as those injected, immobilizing the animals. The antigens thus revealed show hereditary variations which conform to a very complex system, but the main features of this system are now becoming clear[2]. Two distinct forms of variation are found: (1) within stocks, and (2) between stocks. A single stock of paramecia, consisting of animals derived from a single homozygous individual, may produce animals of diverse antigenic type. Such diversities are developed in the absence of gene mutation or gene substitution and have been shown in variety 4 by Sonneborn[3] to be due to changes in the cytoplasm. Secondly, different stocks do not develop the same range of antigens: corresponding antigens in different stocks may differ in various degrees one from the other, and some stocks may fail altogether to produce antigens commonly found in other stocks. These diversities between stocks have been shown in variety 4 to be gene-controlled[4]. Thus both gene and cytoplasmic variations are found.

In variety 1 of *P. aurelia*, evidence is now to hand (Beale, unpublished) indicating close agreement in fundamentals with the variety 4 system. The following example will show the kind of behaviour found in variety 1. Paramecia of stock 90 when grown at 25° C. produce the antigen designated type *Z*; but if these '90*Z*' paramecia are transferred to a temperature of 29° C., all transform, after a variable number of

fissions, to another antigenic type, namely, *Y*. Similarly stock 60, collected from a different locality from stock 90, produces at 25° C. type *X* and at 29° C. type *W*. Breeding experiments show that these two stocks differ in respect of two independently segregating pairs of genes. Thus stock 90 may be given the genetic formula $y^{90}z^{90}$ and stock 60 $y^{60}z^{60}$. If the two stocks are crossed, and $F_2$ generations raised, new types are obtained: a type $y^{90}z^{60}$ which produces *Y* at 29° C. and *X* at 25° C., and a type $y^{60}z^{90}$ which produces *W* at 29° C. and *Z* at 25° C.

The peculiar feature of this system is that the products of the genes *y* and *z* are mutually exclusive; except for the temporary period of transformation from type *X* to *W*, or from type *Z* to *Y*, mixtures of the antigens *X* and *W*, or *Z* and *Y*, are not found in the same animal. Consequently, it is concluded that at 29° C. the alleles at the *y* locus are able to exert their effect on the phenotype, and the processes initiated by the *z* alleles are inhibited, while at 25° C. the situation is reversed.

Further analysis is possible owing to the fact that temperature-induced transformations do not occur at once, but usually only after a considerable number of fissions. It is therefore possible to make crosses of the type $90Y \times 60X$. When this is done, it is found that the gene $z^{60}$ from stock 60, on introduction into cytoplasm derived from the 90*Y* parent, immediately ceases to influence the phenotype. The gene $y^{60}$, however, which had been without effect on the phenotype of the original 60*X* parent, immediately manifests itself on introduction into cytoplasm derived from the 90*Y* parent. These changes may occur without any variation in temperature, and it is therefore evident that some component of the cytoplasm is able to inhibit the processes initiated by one gene and favour those initiated by another gene. The cytoplasm in its turn is influenced by the external environment, namely, the temperature. A more detailed account of this work will be presented elsewhere.

To sum up, there is in each stock of *P. aurelia* a series of genes, at separate loci, corresponding to each of the antigens which that stock can form, but only one of these genes can produce its effect on the phenotype at a given time. Which one of the genes is active depends on the state of the cytoplasm surrounding the genes, and the state of the cytoplasm is controlled by the environment. This system, which has been analysed for variety 1 stocks, does not conflict with the data previously obtained by Sonneborn and colleagues, using variety 4.

## The Killer System

Certain animals of *P. aurelia* have the property of liberating into the water a poisonous substance, paramecin, lethal to all sensitive animals. The determination of ability to liberate this substance has been thoroughly investigated, and the results published[5,6,7]. Here only the following established facts need be mentioned. The production of paramecin is due to the presence in the cytoplasm of some hundreds of kappa-particles, which are known to contain deoxyribosenucleoprotein, and to be about 0·2–0·8 μ in size. Kappa-particles can only be formed in the presence of pre-existing kappa-particles. If, through adverse conditions, they should be lost from the cytoplasm, no more can be formed except by introduction from the cytoplasm of another individual during conjugation, or rarely from the external medium[4]. Such introduced particles do, however, multiply in exactly the same manner as the original ones. Several different kinds or mutants of kappa are known[7], distinguished by the different modes of killing by the paramecins they produce, and by the fact that animals sensitive to one kind of killer may be resistant to another.

Kappa-particles are, however, only developed in paramecia of specified genotype. In particular, in variety 4, the gene *K* is known to be essential, and if this gene is replaced by its allele *k*, any kappa-particles which may be present are soon destroyed[6]. Finally, external conditions such as food supply are known to affect the rate of reproduction of kappa independently of the reproduction of the paramecium[6].

## Comparison of Killer and Antigen Systems

From the foregoing it is evident that the three factors—nuclear, cytoplasmic and environmental—interact in a totally different manner in the killer and antigen systems (as pointed out by Sonneborn[1]). The specific determinants of the various kinds of killer character are the kappa-particles in the paramecium cytoplasm, whereas the specific determinants of the antigens are certain genes in the paramecium nucleus. In each case, however, the specific determinants require the aid of the other, 'non-specific', factors. In the killer system the 'non-specific' factors include the gene *K* in the paramecium nucleus, the amount of food and the temperature; in the antigen system the 'non-specific' factors include some unidentified component of the paramecium cytoplasm and the temperature. By 'non-specific' is meant here a factor which favours not one particular kind of killer or one particular antigen, but one which favours a number of variants of the character in question. Just as the gene *K* is able to support the maintenance of a number of distinct kappa mutants, so a given kind of cytoplasm is able to favour the processes initiated by a number of allelic genes controlling antigen production.

These facts may be expressed in a different way by saying that with the killer system there is an essential reproducible model in the cytoplasm of the paramecium, while in the antigen system the only essential reproducible models, so far as is known at present, are the nuclear genes.

The chief importance of such systems as these is that they enable us to formulate models of the processes by which cells containing identical genes may develop along diverse pathways[1,2]. This problem is one of the most formidable with which geneticists are confronted at the present time. It is usually assumed that since all, or nearly all, the cells of a multicellular organism contain the same number and kind of genes, the diversities which develop must in some way be controlled by components of the cytoplasm. The question now arises: Which of the two models offered by paramecium is the more useful in this connexion? A number of attempts have been made to use kappa-like models, for example, in the plasmagene theories favoured by a number of recent writers. But actual demonstration of the existence of gene-like cytoplasmic particles has been limited to a very small number of examples. For example, in *Drosophila melanogaster* only a single example[8] is known, in contrast to the hundreds of nuclear genes in the same organism. It may be that there are special reasons why detection of such particles is technically difficult, as Sonneborn[1] points out; but for the moment it seems to me more reasonable to consider them more in the nature of infective,

'symbiotic', organisms than as hereditary units of the host[10]. Existing data do not permit us to decide whether the distinction between the two concepts is a real one, or merely formal.

The antigen system here brought forward, and elsewhere discussed extensively by Sonneborn, could, however, be readily accommodated into existing genetical theory, and would extend such theory to new lines of study. Nevertheless, it must be admitted that we have at present no knowledge of the nature of the hypothetical substances in the cytoplasm which are able to favour one series of gene-controlled reactions and to inhibit others. These 'substances' may be simply certain physico-chemical conditions; they may be definite chemical compounds; or again they may be more complex aggregates having certain of the properties of genes. If these substances or conditions could be identified, we should have made an advance in our understanding of cellular differentiation in higher organisms.


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# PROPOSED NEW VALUE FOR THE VELOCITY OF LIGHT


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THE evidence supporting a rather higher value for the velocity of light than that used during the past few years continues to accumulate. Since the article published in *Nature* last year[1], a provisional value of 299,789·3 ± 0·4 km./sec. has been announced by Dr. Kees Bol[2], of Stanford University. Further work is reported to be in progress there; but it is expected that the final result is unlikely to differ from this figure by more than 0·5 km./sec. The cavity resonator method is used, the experiment having been devised and supervised until his death in 1949 by W. W. Hansen, whose pioneer work on resonators is well known. The design of a cavity to resonate at a particular frequency is governed by its dimensions and by the velocity of the waves; and the idea of reversing the process, and calculating the velocity from the dimensions and the frequency, must have occurred independently to many workers in this field. But although the method is so simple in principle, it is not so easy to carry out the measurements with the accuracy required to make the results of interest. At the National Physical Laboratory the problem was approached in two stages, the simplest possible type of apparatus being used first, and a more elaborate equipment then being made in the light of the experience thus gained. In both stages the experiment was designed to eliminate as far as possible the errors caused by the departure of the resonator from the perfect cylindrical form. The preliminary experiments, however, gave a precision of measurement considerably greater than that of any previous determination, and it is rather surprising, therefore, that this method has not been used by other workers.

At Stanford University, on the other hand, the experiment was designed from the outset to give the highest possible accuracy, the small errors due to imperfections in the cylinder being determined by calculation and measurement. These different methods of approach led to a quite different form of cavity, and the reasonably good agreement between the National Physical Laboratory and the Stanford University results is therefore all the more significant.

The question arises: What is the best value to adopt for the value of the velocity of light? There can no longer be any reasonable doubt that the value hitherto most widely accepted, namely, that of 299,776 ± 4 km./sec., derived by Birge from a statistical appraisal of the earlier optical determinations, is no longer acceptable. To arrive at a new estimate it is necessary to examine not only the various values that have been obtained but also the limits of error, and it is interesting to note that there can be no better example in the history of science of the difficulty of assessing limits of error than that afforded by the measurement of the velocity of light. No rigorous attempt will be made here; but from general considerations of the precision of the observations, it would seem reasonable to give the optical results summarized by Birge and the first value obtained at the National Physical Laboratory one half of the weight of the other individual results obtained during the past few years. The results obtained by Houstoun[3] and McKinley[4] are close to Birge's value, but their precision seems to be rather less than that of the early optical results. They cannot, therefore, be given much weight and will be regarded as included in Birge's value. The tabulated results are then as follows:

| Author | Method | Velocity *in vacuo* | Weight |
|---|---|---|---|
| Birge | Optical | 299,776 ± 4 km./sec. | 1 |
| Essen and Gordon-Smith | Cavity resonator | 299,792 ± 9 | 1 |
| Bergstrand | Optical | 299,793·1 ± 0·26 | 2 |
| Aslakson | Radar | 299,792 ± 2·4 | 2 |
| Essen | Cavity resonator | 299,792·5 ± 3 | 2 |
| Bol | Cavity resonator | 299,789·3 ± 0·4 | 2 |

Resultant mean value, 299,790·2.

It is suggested, therefore, that the value 299,790 km./sec. be adopted until still more accurate measurements have been made.

The final value of Bergstrand's optical determination[5] is 0·4 km./sec. higher than that given in the previous article because of his adoption of a slightly higher value for the refractive index of air. The refractive index of dry air at a specific optical wavelength is believed to be known to ± 5 × $10^{-8}$, so that even when allowance must be made for the colour of the source and the effect of humidity, the error due to the uncertainty of the refractive index of the atmosphere may be kept below ± 1 × $10^{-6}$ in measurements of velocity of light. The position is less satisfactory at radio-frequencies, partly because the effect of water vapour is much greater and partly because the refractive index (or dielectric constant) of dry air is not known so accurately. The values extrapolated by the use of a Cauchy-type of dispersion formula from the different optical measurements agree to ± 2 × $10^{-7}$; but it is known that there are absorption bands in between the optical and radio-frequencies, and their effect on the dispersion of air, although likely to be small, cannot be assumed to be negligible. On the other hand, the measurements of the dielectric constant of air at radio-frequencies

have given widely divergent results. The difficulty was avoided in the cavity resonator experiments by the complete evacuation of the resonators; but it cannot be avoided in the radar method or in methods now being developed in the Metrology Division of the National Physical Laboratory for the measurement of length and velocity by the interferometry of radio waves. A measurement of the dielectric constant of air at radio-frequencies is required with an accuracy comparable with that obtained at optical frequencies. The problem is being investigated by Drs. K. D. Froome and L. Essen, and, although the work is not yet complete, it is clear that the value at 24,000 Mc./s. will not differ greatly from that obtained by extrapolation from the well-established dispersion formulæ for optical frequencies.

The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this article is published by permission of the Director of the Laboratory.

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# OBITUARIES

## Prof. S. A. F. White

STUART ARTHUR FRANK WHITE, of Wadham College, Oxford, and Fellow of King's College, London, died on January 12 after a short illness at the age of eighty.

'SAF' White, as he was affectionately known by several generations of colleagues and pupils, was appointed demonstrator in natural philosophy (on the recommendation of the Engineering Committee!) at King's College, London, at the end of 1894. The head of that department was William Grylls Adams, who had held the chair since 1865. White became professor of mathematics in January 1904, in succession to W. H. H. Hudson, and when Adams retired in 1905 applied mathematics was transferred to the Department of Mathematics.

White never lost his sympathy with the science or engineering student. He was a stimulating teacher, always anxious to make contact with a class at the level they had reached before attempting to lead them on. Any newly appointed junior had to develop his pet topics in his own research rather than in classes for undergraduates.

There was a satisfying wholeness about White's college life. King's College was his first concern, but as an organism composed primarily of colleagues and students. Like W. T. Gordon (who, fourteen years his junior, predeceased him by a month) he was until his death one of the trustees of the Union Society, and both were of a small company who gave to the first college hostel ("The Platanes" on Champion Hill) its furniture and equipment in 1914. It was characteristic of him that he retired three years earlier than he need have done, so that the Department should not lose three senior members in two years.

White's voice was never strong, and in his later years trouble with his vocal cords, though painless, reduced it to a hoarse whisper and led to a seclusion which was quite against his nature. He had always been a valued member of the Senior Common Room, and was its honorary secretary at the time of his retirement and for two years afterwards. J. T. COMBRIDGE

## Mr. G. Fox Wilson

IT is with much regret that we record the death, on January 9, at Weybridge Hospital, at the comparatively early age of fifty-four years, of George Fox Wilson, whose life-work in the applied aspects of economic entomology was outstanding.

Fox Wilson was born on January 26, 1896, was educated at King Edward VI School, Grantham, and went to the Royal Horticultural Society's Gardens at Wisley as a student in 1911. He won a scholarship awarded by the Worshipful Company of Gardeners, and remained at Wisley, working as assistant to the then entomologist, Prof. H. Maxwell Lefroy, until the summer of 1915. He then spent four years in the Services, in the 1st City of London Sanitary Company, passing three years in Egypt and Syria, where he devoted his time to anti-malaria work and other problems of an entomological nature. He returned to Wisley in 1919, occupying the post of head of the Entomological Department until his death.

Fox Wilson made a detailed study of the insects and allied animals associated with cultivated plants, trees and vegetables, and before long was recognized in Great Britain and abroad as the leading authority in this field.

Among many important research problems which interested him, a study leading to the control of eelworm of chrysanthemums and phlox was outstanding, and his recommendations for their eradication are followed by those concerned with these pests. Greenhouse fumigation problems, seed storage, and the testing of new insecticides also formed part of his investigations.

Fox Wilson's publications were varied, and the principal work, entitled "The Detection and Control of Garden Pests", was published in 1947; to-day, it is regarded as the standard work on the subject. Another notable publication appeared in 1937, namely, "The Pests of Flowers and Shrubs", of which the second revised edition recently appeared. His innumerable scientific publications in the *Journal of the Royal Horticultural Society* and the journals of other learned societies are also of a very high standard.

Fox Wilson became a member of the Royal Entomological Society in 1920, was vice-president in 1940, 1941 and 1947–48; and he served on the Council on three occasions. He joined the Association of Applied Biologists in 1920, and was made general and zoological secretary for 1935–36, and zoological secretary during 1933–34 and 1937–38, serving on the Council during 1927–29. In recognition of his services to the Association, he was elected president in 1949–50.

He leaves a widow and two very young sons, and to them we extend our deep sympathy in their bereavement. A. M. MASSEE

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WE regret to announce the following deaths:

Sir Eustace D'Eyncourt, Bart., K.C.B., F.R.S., director of naval construction and chief technical adviser to the Admiralty during 1912–23, on February 1, aged eighty-two.

Mr. G. P. Millett, C.I.E., formerly conservator of forests, Bombay Presidency, on December 29, aged eighty-seven.

Mr. H. Stainton Tireman, C.I.E., sometime chief conservator of forests, Madras, on January 11, aged seventy-nine.

# NEWS and VIEWS

## Guthrie Lecture of the Physical Society: Prof. N. F. Mott, F.R.S.

The Physical Society has appointed Prof. N. F. Mott, of the H. H. Wills Physical Laboratory, University of Bristol, to deliver the thirty-fifth (1951) Guthrie Lecture. This is an annual award instituted in memory of the founder of the Physical Society. Prof. Mott's subject will be "The Mechanical Properties of Solids", and the Lecture will be given in the Science Museum, Exhibition Road, London, S.W.7, on March 16, at 5 p.m. Prof. Mott left Cambridge in 1933 to occupy the chair of theoretical physics at Bristol, later, in 1948, becoming director of the Wills Laboratory. He has contributed much to the study of the solid state. Moreover, by summer schools and small conferences in the Wills Laboratory he has done much to familiarize other workers, both academic and industrial, with the modern approach to old problems in this field. In the first place, his interest was in the theory of metals and alloys, and his treatise on this subject with H. Jones (1936) contained much original material and is still a standard work. He then turned his attention to semiconductors and insulators, and there followed another volume, with R. W. Gurney, on "Electronic Processes in Ionic Solids". His theory of the photographic latent image also attracted much interest. During the Second World War, Prof. Mott's versatility was shown by his contributions to radar and to operational research, and later as superintendent of a theoretical group in the Ministry of Supply. He is a Hughes Medallist of the Royal Society and holds honorary doctorates of the Universities of Louvain and Grenoble.

## New Portable Television Equipment

A new range of portable television equipment for use in studios or for mobile outside-broadcasting stations has been designed and produced by the Marconi's Wireless Telegraph Co., Ltd. An outstanding feature of this equipment is the television camera using the famous 'Image Orthicon' pick-up tube, which has played such an important part in many recent B.B.C. television broadcasts. The extreme sensitivity of 'Image Orthicon' tubes enables them to provide good pictures by the light of a single candle; at the same time they will operate without adjustment over a wide range of light intensities, a valuable feature for the conditions often met in televizing outdoor events. The new camera includes a four-lens rotatable turret, operated from the rear by the camera operator. Focusing is done by racking the camera tube and reflexion assembly relative to the lens. On account of the fact that an optical view-finder cannot work down to the low light-levels sometimes experienced, an electronic view-finder is used. This unit, which clips on top of the camera, contains a small vision monitor tube in which the operator sees the actual image his camera is picking up. All the accessory equipment is contained in units of convenient size and portability, to enable the whole installation to be set up quickly in studios or in mobile television vehicles.

## A New Systemic Insecticide

The development of organo phosphorus insecticides is proceeding apace. Messrs. Pest Control, Ltd., Harston, Cambridge, announce that they will shortly be putting on the market, under the trade name of 'Isopestox', a new compound, *bis iso*propyl-amino-fluorophosphine oxide, the oral toxicity of which to rabbits and guinea pigs ($LD50$ = 80–100 mgm. per kgm.) is said to be only one twenty-sixth that of 'Parathion', one-ninth that of nicotine and rather more than twice that of DDT. It is well translocated by the plant and thus when applied to the roots by watering the soil it has a selective action against plant-feeding insects. Exact details of toxicity to the various insect pests are not yet available; but it is expected to be useful against lettuce aphids, which are largely inaccessible to ordinary insecticides. Considerable success in aphid control has been achieved with 'Pestox 3', the chief constituents of which are *bis* (dimethylamino) phosphonous anhydride and triphosphoric-penta-dimethyl-amide; but the high toxicity of this material to man and its long persistence in the plant (see *Nature*, **165**, 100; 1950) have naturally raised doubts about the advisability of applying it to crops that are to be harvested for human consumption. The new compound is much less poisonous to man and is said to be completely hydrolysed by the plant within sixteen days.

## British Museum Newspaper Library: Microfilm Annexe

Before the Second World War the British Museum Library collection of newspapers was housed in a two-story building at Colindale. This building collapsed in October 1941 as a result of bomb damage; but about three-quarters of the bound volumes were saved. The Museum had the problems of sorting the damaged material and of housing the annual intake of new newspapers—some 2,500 volumes occupying about 120 yards of shelving. Soon after the War, Sir John Forsdyke, who was then director and principal librarian, decided on the use of microfilms and the transfer to storage of volumes of newspapers. The Rockefeller Foundation of New York generously provided five cameras, a processing machine and a printing machine, with ancillary equipment. The Ministry of Works has now been able to erect a small building on the site of the destroyed wing at Colindale as a microfilm studio, and two temporary sheds for the sorting of the newspapers rescued from the destroyed building. The design of the microfilm annexe was based on a suggestion by Mr. Eugene B. Power, of Ann Arbor, Michigan, who has given the Museum much assistance in planning and carrying out this scheme. Non-inflammable 35-mm. film is used. The cameras have automatic travelling book-holders, so that opposite pages of a bound volume alternately come into position under the camera, which is supported above the book on a vertical pillar. In the processing machine, which is a modification of a type used in film studios, the film passes continuously over rollers through tanks of developer and fixer, and through washing and drying chambers at the rate of 2,000 ft. per hour. The automatic printer is also the microfilm version of a machine developed for motion-picture work. One thousand feet of positive can be printed in about thirteen minutes. Enlargements of the microfilm up to the original size of the newspaper can also be made. The Rockefeller Foundation gift included a number of microfilm reading machines specially suitable for newspaper work. The image of the film is projected on to a mirror at the back of a metal box and from this on to a greenish translucent reading screen, by the movement of which the image can be adjusted to the

most comfortable size. For the present, all newspapers (except London newspapers before 1800) will continue to be consulted at Colindale; those which have been microfilmed will be consulted on film in the reading machines. Eventually it is hoped that accommodation for consultation of these microfilms will be available in the main Museum Library at Bloomsbury.

## Vegetation Patterns in Somaliland

In a paper entitled "Vegetation Patterns in the Semi-desert Plains of British Somaliland" in the *Geographical Review* (116, 199; 1950), Dr. W. A. Macfadyen develops in some detail a thesis put forward in a letter in *Nature* (165, 121; 1950) that the arc-shaped ripple-like marks seen in air photographs of this semi-desert country are caused not, as sometimes believed, by wind erosion, but by the rhythmical arrangement of concentrations of vegetation. Accompanying photographs afford evidence of the existence of vegetation arcs, and the origin of these arcs is attributed by Dr. Macfadyen to the effect of storm water carrying along seeds, vegetation debris and animal excreta which are deposited in the form of strand lines giving rise to vegetation arcs. That the operative agent is water rather than wind is suggested by the fact that the arcs are always oriented so that their chords are at right angles to the direction of drainage, with their convex edges upslope. Sometimes the arcs are cut through, at right angles to their chords, by "water lanes" which are clearly visible on air photographs, but have not been identified on the ground. They appear to be drainage channels produced by flows of water which are more localized and intense than those producing the vegetation arcs. The detailed processes by which the vegetation arcs and water lanes are formed are obscure; but the phenomena are of sufficient interest to warrant further study. In particular, it is important to ascertain beyond question whether overgrazing, which is reputed to have caused much damage through wind erosion, is in fact occurring at all.

## Sources for Social and Economic Research in Great Britain

The standing Interdepartmental Committee on Social and Economic Research, which is composed of academic as well as departmental members, exists to survey and advise upon research work in government departments, to consider the extent to which material collected by departments is of potential value to research in the social sciences, to suggest new methods and areas of collection, and to advise how the information gathered can be made available to research workers. In 1948 the Committee issued as its first guide to official sources a descriptive survey of the material collected by the Ministry of Labour and National Service; a revised edition, which takes account of the changes of man-power and of the insured population brought about by the introduction of the National Insurance and National Insurance (Industrial Injuries) Acts and of the Standard Industrial Classification, has recently been published (Guides to Official Sources, No. 1; pp. 38; London: H.M. Stationery Office, 1950; 1*s*. 3*d*. net). Besides reviewing the information collected by the Ministry, the booklet refers to factors affecting the continuity of statistical series and includes a list of the principal published sources of labour statistics. Appendixes contain notes on the principal measures administered by the Ministry, a subject index to published sources of the Ministry's statistics, specimen forms used by the Ministry, references to sources of information on international labour statistics, definitions of employment and a list of Ministry of Labour and National Service Employment Exchanges and Branch Employment Offices by region and county. The revised edition should continue to be of real service to teachers and students in the universities as well as to other research workers.

## Wattle Research Institute, Pietermaritzburg: Annual Report for 1949

In 1948 the combined exports from South Africa of wattle bark and extracts represented nearly a quarter of a million tons of dry bark, and it is expected that the exports for 1949 will exceed £5 million in value. Much of these wattle products goes to hard-currency areas, and the remainder is the main source of vegetable tanning material within the sterling area. Altogether, although the ground under wattle in Natal and eastern Transvaal is probably more than half a million acres in area, the world demand is greater than the immediate capacity to supply. Thus there is at the present time a great opportunity for expanding the industry; but it is imperative that any future development should be wisely planned. In this respect, the Wattle Research Institute, which forms a part of the Natal University College, recently raised to the status of the University of Natal, has an important part to play. The first report of the Institute was mainly historical and now the second annual report, which is for 1949 (pp. 43; Pietermaritzburg: Wattle Research Institute, 1950), indicates that a good start has been made and on correct lines. For example, a tour in 1949 is described, undertaken on behalf of the Colonial Development Corporation, to ascertain whether conditions in certain areas of Tanganyika and Nyasaland are suitable for large-scale wattle cultivation. The investigation was undertaken by S. P. Sherry, of the Research Institute. The investigations undertaken are carefully described. They resulted in a recommendation that forty thousand acres of plantable land could be used for a wattle project and supply a factory output of eight hundred tons. Other land will later gradually be available, and the factory is to be constructed so as to make extensions possible. The survey made in certain areas in Nyasaland, on the other hand, did not result in areas of land of a suitable size and so forth being available to enable a factory project to be drawn up, and, for the time being, no proposal for starting plantations was made. This forms a striking example as to how African land development, with particular objects in view, should be undertaken. Such disasters as the Kongwa groundnut scheme are thereby avoided.

## Forestry Commission Research: Annual Report for 1948–49

The Forestry Commission has recently published a report on forest research for the year ending March 1949 (pp. 80; London: H.M. Stationery Office, 1950; 1*s*. 9*d*. net). The report is divided into three parts: Part 1 deals with the work carried out by the Forestry Commission staff, Part 2 with the Committee on Nutrition Problems in Forest Nurseries, and Part 3 with research undertaken for the Forestry Commission by workers attached to the universities and other institutions. The headquarters of the Forestry Commission research is at the Research Station, Alice Holt, the alterations and adaptation of which

are now nearing completion. The work on nutrition problems in forest nurseries is being carried out by Dr. E. M. Crowther, of Rothamsted, and by his staff, in co-operation with the Commission's research officers, and is under the guidance of a committee presided over by Prof. F. T. Brooks. The work of the forest research officers of the Commission is described in Part 1 under the headings of studies of growth, pathology, entomology, genetics, forest ecology, the treatment of seed, experimental work in the nursery, afforestation of peat, planting experiments on lowland heaths, provenance studies, arboreta and forest gardens. In the introduction Mr. James Macdonald, director of research and education, refers with great regret to the sudden death of Dr. M. C. Rayner, who did so much valuable research work in connexion with forest nurseries in Great Britain. In Part 3 Mr. M. V. Laurie, chief research officer, gives a general note on work that has been undertaken during the year, such as soil faunal investigations, research into the physical and chemical properties of forest soils, forest soil investigations in Scotland, researches in soil mycology, investigations on *Fomes annosus* attacks in East Anglian pine plantations, botanical studies on tree races and forest ornithological investigations.

## The *American Naturalist*

The *American Naturalist*, which was established in 1867, has become, beginning with the eighty-fifth volume, the journal of the American Society of Naturalists and will be issued six times a year by the Science Press, Lancaster, Pennsylvania. Dr. L. C. Dunn, of Columbia University, has been appointed managing editor, and an editorial board, consisting at present of Prof. G. E. Hutchinson (Yale University), Prof. Thomas Park (University of Chicago), Dr. G. L. Stebbins (University of California) and Prof. Conway Zirkle (University of Pennsylvania), is in process of formation. The policy of the journal will be to continue its service to general biologists and naturalists in correlating the various biological sciences by the publication of essays, addresses, and symposia of biological societies; space will also be given to reports of new research, preference being given to those in which the chief inherent interest is in theoretical interpretation and synthesis. Editorial material should be sent to the editor of the *American Naturalist*, Box 2, Schermerhorn Hall, Columbia University, New York 27, N.Y.

## Foreign Scholarships for British Students

The British Council has published a list of some seventy scholarships for the academic year 1951–52 offered by fifteen foreign governments and universities to British students. Although mainly for postgraduate study, some scholarships are open to those not yet graduated and to those with non-academic professional qualifications. They provide free tuition and maintenance, and the majority are tenable for the complete academic year, with a few for shorter periods. The countries concerned are: Austria, Belgium, Brazil, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Persia, Portugal, Spain, Sweden and Switzerland. The scholarships in most cases correspond to those offered by the British Council to foreign students from these countries, and the list is not therefore comprehensive of all the scholarships that are tenable abroad by British students. Closing dates for applications vary for each country, the earliest being March 7. Details of these scholarships are contained in a booklet of forty-six pages, issued by the British Council, which is remarkable for its comparative lavishness, particularly in the use of space; thus a certain address, spaced out into five lines of print, is repeated no less than eighteen times. Presumably all this information is for circulation in Great Britain only, and duplicated typescript sheets might have served. The booklet and application forms for scholarships are obtainable from the British Council at 65 Davies Street, London, W.1, or at any one of its regional and area offices.

## Nuffield Foundation Awards in Dentistry

To help the advancement of teaching and research in dental health and disease, the Nuffield Foundation is offering a number of fellowships to enable men and women with dental qualifications to receive additional training in pure and applied science that will fit them for an academic career in dentistry, and also to enable university graduates in medicine and science to receive training that will qualify them to undertake teaching and fundamental research on dental health and disease; in the latter case, it is not expected every fellow will necessarily study to obtain a registrable dental qualification, and the Foundation hopes that there will be an increased number of applicants for this type of fellowship as compared with the disappointing response of last year. The annual value of all the fellowships is £500–800, and they will be awarded for one to three years. Scholarships, normally tenable for one year, are also available for students at university dental schools in the United Kingdom; these scholarships cover tuition fees and include a subsistence allowance of not more than £200 a year. Application forms for fellowships must be returned by March 1, and for scholarships by June 30; these forms are obtainable from the secretary of the Nuffield Foundation, 12 and 13 Mecklenburgh Square, London, W.C.1.

## Summer School on Social Biology and Health

A summer school on "Social Biology and Health" will be held at Wadham College, Oxford, during August 20–September 3. The School is intended for all who are interested in public and personal health and for teachers of pre-nursing courses and biologists taking non-academic courses in sixth forms, as well as for lecturers in health education in training colleges and health visitors. Miss P. M. Taylor, of Homerton College, Cambridge, president of the Association of Women Science Teachers, and Mr. L. J. F. Brimble, chairman of the British Social Biology Council, will direct the School. Among those who have already agreed to take part are Prof. Fred Grundy, Mansel Talbot professor of preventive medicine in the Welsh National School of Medicine, Cardiff; Dr. J. L. Burn, medical officer of health, Salford; Dr. Hugh Sinclair, director of the Laboratory of Human Nutrition, Churchill Hospital, Oxford; Sir Thomas Dalling, of the Ministry of Agriculture and Fisheries Veterinary Laboratory at Weybridge; Dr. Josephine Macalister Brew, educational adviser to the National Association of Girls' Clubs and Mixed Clubs; Dr. Celia Westropp, physician-in-charge of the Child Health Survey, Institute of Social Medicine, Oxford; Dr. Lee, vicar of the University Church; Mr. W. Combey, chief sanitary inspector, Oxford; and Mr. R. Weatherall, editor of *Biology and Human Affairs*. Lectures will cover a wide variety of topics, including

child health, nutrition, mental health, housing, animal health, the prevention of disease, municipal and industrial health, etc. A number of excursions have been planned, among them being visits to the Elan Valley, the Cotswolds (Burford, Broadway, Fairford, the Rollright Stones, etc.), Stratford-on-Avon (including a performance at the Memorial Theatre), and Bath (via Wells, Glastonbury and Cheddar). The cost of the School will be £16 16s., including full board at the College, and it is jointly sponsored by the Association of Women Science Teachers, 11 Fillebrook Hall, Fillebrook Road, Leytonstone, E.11, and the British Social Biology Council, Tavistock House South, Tavistock Square, W.C.1, from whom further information can be obtained.

## World Metallurgical Congress in Detroit

A WORLD Metallurgical Congress, sponsored by the American Society for Metals, will be held in Detroit, Michigan, during October 15–19. Dr. Zay Jeffries, former president of the American Society for Metals and former vice-president of the General Electric Co., will be director-general. Simultaneously with the Congress the Thirty-Third Annual National Metal Congress and National Metal Exposition will be held in Detroit during October 11–20. Invitations are being sent out to industrial countries to send national teams made up of technologists, men of science, production executives, and sales engineers in the metal-producing and -fabricating industries. These representatives will meet in New York City on September 10 and will be divided into groups according to the interest of the individual. The groups will then go on guided tours for three weeks, visiting important plants and institutions, before finishing up at Detroit for the Metal Congress and Exposition. Details of the members of national teams should be completed by May 1. At the World Congress the programme on the exchange of information and latest industrial techniques will be divided into the following headings: steel making and refining; preparation of metals for economic fabrication; fabrication of metals; research in metals; marketing; national engineering societies; and metallurgical instruction at university and postgraduate level. Discussion will also take place on the conservation, utilization and substitution of strategic metals. The official languages of the Congress will be English and French. Further details can be obtained from W. H. Eisenman, secretary of the American Society for Metals, 7301 Euclid Avenue, Cleveland 3, Ohio.

## Conference on Automatic Control

A CONFERENCE on "Automatic Control" is to be held at the College of Aeronautics, Cranfield, Bedfordshire, during July 16–21, 1951. The papers and discussions, which should be of particular interest to engineers, physicists and mathematicians concerned with the theory, design, production and testing of automatic control systems, and their use in industry, will cover the following main topics: automatic control systems (general theory and problems of synthesis); servo control systems (non-linearities); process control, including inter-relation with servo control; and the human operator. Other more specialized topics may be included, and there will also be provision for a limited display of automatic control apparatus. The conference is sponsored by the Department of Scientific and Industrial Research, and the organizing committee is under the chairmanship of Prof. A. Tustin, professor of electrical engineering in the University of Birmingham. The accommodation at Cranfield can only hold about 250, and it will be necessary to limit attendance to leading workers in the field of automatic control. Further information can be obtained from the Secretary of the Organizing Committee, Conference on Automatic Control—1951, D.S.I.R., Charles House, Regent Street, London, S.W.1.

## Human Factors in Equipment Design

A SYMPOSIUM on human factors in equipment design will be held by the Ergonomics Research Society during April 18–21 in the University of Birmingham. Membership of the symposium will be open to anyone, whether a member of the Society or not, who is interested in the application of anatomical, physiological and psychological knowledge to the design of equipment. After the opening session on April 18, the morning and afternoon sessions on April 19 and 20 will be devoted to, respectively: physical anthropometry and problems of seating and posture, visual and auditory displays, muscular force and work, and speed of performance. There will be a short final session on April 21, at the end of which Sir Frederic Bartlett will give a concluding address. Accommodation for those attending the symposium will be provided in one of the hostels of the University. Further inquiries should be addressed to the symposium secretary, Miss B. G. Murrell, 219 Cromwell Mansions, Cromwell Road, London, S.W.5.

## Announcements

THE Section of Science of the Royal Netherlands Academy of Sciences and Literature has awarded the Leeuwenhoek Medal to Prof. S. A. Waksman, professor of soil microbiology in Rutgers University, New Brunswick, N.Y. This Medal, which is in gold, is awarded every ten years to commemorate the discovery of micro-organisms by Antony van Leeuwenhoek.

PROF. GASTON DUPOUY, honorary dean of the Faculty of Sciences of the University of Toulouse and director since 1950 of the Centre National de la Recherche Scientifique, has been elected a non-resident member of the Paris Academy of Sciences in place of the late E. Cotton. Prof. Dupouy is well known for his experimental and theoretical research work in magnetism and magneto-optics and also in electron optics, including the electron microscope.

THE Commission Internationale des Industries Agricoles has issued recently a number of bibliographies dealing with mineral nutrition of plants, influence of ultra-violet radiation on amino-acids and proteins, corrosion of metals by sea-water, marking fish for migration studies, artificial ageing of alcoholic liquors, etc. Most of the abstracts are in English or French. Copies of these bibliographies are available on loan in Great Britain, on application to: Research Department, Saml. Hanson and Son, Ltd., Toddington, Cheltenham, Glos. No charge will be made beyond that necessary to cover the cost of packing and postage. Inquiries for the purchase of the bibliographies should be addressed to C.I.I.A., 18 Avenue de Villars, Paris, VII$^{e}$.

ERRATUM. In the communication entitled "Folic Acid, Vitamin $B_{12}$ and Nucleic Acid Synthesis in *Lactobacillus casei*" by D. V. Rege and Dr. A. Sreenivasan published in *Nature* of December 30, p. 1117, the quantities of supplement mentioned in col. 1 of the table should be "mμgm.", not "μgm." as printed.

# WATER-SOLUBLE SILK: AN α-PROTEIN

By E. J. AMBROSE, Dr. C. H. BAMFORD, Dr. A. ELLIOTT and W. E. HANBY
Courtaulds, Ltd., Research Laboratory, Maidenhead, Berks

THE ability of concentrated aqueous solutions of certain inorganic salts, notably thiocyanates and some halides of lithium, sodium and calcium, to dissolve silk fibroin was discovered in 1925 by von Weimarn[1]. This worker also found that by dialysis most of the electrolyte can be removed from a sodium thiocyanate dispersion of fibroin[2], leaving a "turbid and rather viscous" solution of fibroin in water, which usually solidifies after some days. Von Weimarn was apparently of the opinion that the fibroin was at least partially hydrolysed by the salt solutions[1], and Harris and Johnson[3], from a study of dispersions in lithium bromide and calcium thiocyanate solutions, concluded that the fibroin is extensively degraded by these reagents. This was based on the observation that the amino-nitrogen content appeared to be as high as about 5 per cent of the total nitrogen, indicating a degree of polymerization of approximately 20.

A preliminary examination of a dialysed solution of fibroin in lithium bromide solution convinced us that it was most unlikely that Harris and Johnson's conclusion was correct. We found that strong fibres and films afterwards referred to as lithium bromide silk can readily be prepared from such solutions, a result which in our experience would not be compatible with degradation of the protein to fragments containing only about twenty amino-acid residues. We therefore determined the amino-nitrogen content of the dialysed solutions, and obtained a mean value of 0·13 per cent of the total silk. This is sufficiently close to the values found for natural fibroin (0·07, 0·15, 0·19 per cent, see Meunier and Ray[4], Harris[5], and Klemm and Meyer[6] respectively) to support the idea that no appreciable degradation had occurred during dissolution.

We had previously found that polyglycine and many other synthetic polypeptides are readily soluble in dichloracetic acid at room temperatures[7]. It was therefore not surprising to find that silk fibroin is also readily soluble in this acid; the silk dissolves at room temperatures, giving solutions of high viscosity which are comparatively stable. The intrinsic viscosity of fibroin in dichloracetic acid is approximately 19·5 at 25° (concentration in base moles per litre; mean residue weight taken as 78). After standing for 24 hr. at 25° this falls to 15·8, indicating only a small rate of degradation. For purposes of comparison we may note that the ratio $\eta_{sp}/c$ for fibroin measured in 5 per cent solution in the cupriethylene diamine solvent recommended by Garrett and Howitt[8] is given as 4·3; the true intrinsic viscosity would presumably be less than this. Dichloracetic acid is thus a very convenient solvent for comparing the molecular sizes of various samples of silk; the solutions can be prepared and used without observation of any special precautions such as are necessary with cupriethylene diamine.

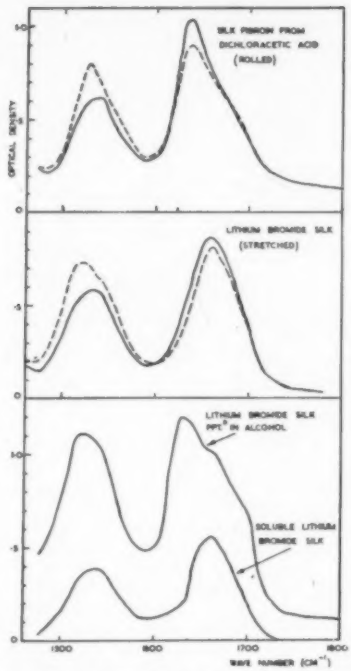
The intrinsic viscosities of natural and lithium bromide silks in dichloracetic acid solutions are found to be 19·5 and 18·5 respectively. This again indicates that the fibroin is not appreciably degraded by dispersion in 60 per cent aqueous lithium bromide at 70°. The nature of these aqueous silk solutions is therefore of considerable interest.

Coleman and Howitt[9] have prepared solutions of silk in water by dissolving the fibroin in aqueous cupriethylene diamine, neutralizing and dialysing. They claim that under these conditions there is no degradation (the intrinsic viscosities in dichloracetic acid of two samples of water-soluble silk prepared by this method have been found to be 13·7 and 12·7 for solution periods of 3 and 10 min. respectively), and suggest that in aqueous solution the fibroin molecule is folded back upon itself twice, this being brought about by a specific co-ordinating action of copper. Such a mechanism is unlikely to apply to the formation of soluble silk using lithium bromide. However, the silk solutions prepared by the different techniques are similar in behaviour; they are both coagulated by shaking, and both yield water-soluble films on careful evaporation. On stretching, both films become insoluble in water. The insoluble form can also be obtained by treatment with the usual denaturing agents (for example, alcohol, acetone, acetic acid, etc.).

The intrinsic viscosity of soluble silk in water is about 7, and appears to be independent of concentration below 0·5 per cent. This suggests that the molecules are very extensively coiled. The possibility that the solution contains micelles roughly spherical in shape is not, of course, excluded. In agreement with this, it has been found that, even in dichloracetic acid solution, silk has an exponent in the Mark–Houwink equation $[\eta] = KM^a$, which is only slightly greater than 1/2, indicating considerable coiling in this solvent. The X-ray diagram of a film of soluble lithium bromide silk shows that the material is completely amorphous. This supports the view expressed above that the molecules are coiled, and further suggests that the coiling is random. To obtain further information on the structure of soluble silk films, they were submitted to infra-red examination.

*Infra-red Results.* Previous work in this Laboratory[10] has shown that the folded (or α-) and extended (or β-) configurations of polypeptides can generally be recognized not only by the dichroism of the NH- and CO-stretching vibrations, but also by the actual frequency of the CO-stretching mode. This is at about 1,630 cm.$^{-1}$ for the extended (β-) form, and 1 660 cm.$^{-1}$ for the folded (α-) form. These frequencies do not appear to vary greatly with the nature of the side-chains, except in the case of polyglycine, where the frequencies are 1,634 cm.$^{-1}$ and 1 690 cm.$^{-1}$ respectively. The frequency of the CO-band in several globular proteins has been found to show a very similar shift on passing from the soluble native to the insoluble denatured state. Elliott, Ambrose and Robinson[11] have suggested that with insulin the soluble crystalline form may be folded in the same configuration as an α-fibrous protein or polypeptide. These observations provide clear evidence of a change in chain configuration on denaturation; this agrees with X-ray observations.

We have now found that a film of lithium bromide silk cast from aqueous solution shows a CO-stretching




Infra-red spectra of silk films. In the upper and middle spectra, the full and broken lines are obtained with the electric vector of the incident radiation perpendicular and parallel to the chain axis respectively

frequency with a peak at 1,660 cm.$^{-1}$, which is highly suggestive of an α-configuration. The insoluble films obtained by treatment with alcohol or ammonium sulphate show a CO-peak at 1,630 cm.$^{-1}$, indicating that the protein chains have been extended into a β-configuration. This is also shown by a shift to lower frequencies of the NH-deformation band. The spectra are shown in the accompanying diagram. The frequencies of other bands (not shown in the diagram) are consistent with an α-form. It will be noted that the conversion to the β-form was not complete. The spectrum of a film of silk cast from dichloracetic acid on silver chloride and oriented by rolling shows a much greater proportion of the β-form (see diagram). This spectrum, observed with polarized radiation, shows the usual dichroism for a β-material[12].

We have made similar observations on a stretched film of lithium bromide silk. The frequency and dichroism of the NH-deformation mode are those to be expected for a β-structure. The CO-band in this spectrum shows low dichroism. It is, however, clear that the maximum dichroic ratio occurs on the low-frequency side of the band; measurement shows it to be at approximately 1,634 cm.$^{-1}$, which is very near the frequency of the peak in the insoluble (β-) material. The silk in these films is evidently still mainly in the unoriented folded form; but sufficient orientation of the β-chains is produced to reveal itself through dichroic effects. Evidently a small amount of the β-form suffices to make the film insoluble in water.

Soluble silk prepared by Coleman and Howitt's technique gives essentially similar results. This provides further evidence that the mechanism of formation and structure of the soluble silk is not that proposed by Coleman and Howitt, since their arrangement of fibroin chains would be indistinguishable spectroscopically from natural silk, both having the β-configuration.

*Conclusion.* The available evidence indicates that in water-soluble films cast from aqueous solutions the fibroin chains are in the α-form. The analogy with some synthetic polypeptide systems is very striking. Bamford, Hanby and Happey[13] have shown that the α- and β-forms of copolymers of DL-β-phenylalanine with L- or DL-leucine differ markedly in their behaviour when treated with non-polar liquids. The α-forms dissolve easily in benzene or carbon tetrachloride, but the β-forms are completely insoluble. Moreover, the presence of a small amount of β-material is sufficient to make the polymers insoluble. As has been shown above, these features are simulated by the silk–water system. It has been pointed out that the differential solubility of the polypeptides is strong evidence that the hydrogen bonds in the α-form are completely intra-chain in character, and presumably the same arguments apply to silk. Thus the results are consistent with the folded form having the $\alpha_{II}$-structure, or certain spiral configurations in which all the hydrogen bonds are intra-chain; but they appear to exclude folds similar to that proposed for α-keratin by Astbury and Bell[14]. (It is assumed that the peptide peptide hydrogen bonds are stronger than those involving water molecules; the insolubility of β-silk in water is consistent with this and there is some infra-red evidence pointing in the same direction.)

We consider that the spectroscopic and viscosity evidence shows that the peptide chains of the soluble silk have secondary folds to such an extent that the molecule is essentially globular. This is also consistent with the presence of an $\alpha_{II}$-primary fold, which, being ribbon-like and flexible, would facilitate secondary folding.

The present results agree with the idea that the silk molecule is composed of two types of segment, containing the residues with small and large side-chains respectively. In the solid state the segments with small side-chains are very unstable when in the folded configuration and pass over to the β-form very readily, thus accounting for the ease with which the protein is rendered insoluble. On the other hand, the segments with large side-chains are stable in the α-form and persist even in the drawn fibre[15]. Bamford, Hanby and Happey[7] have shown that small side-chains decrease the stability of the α-forms of the synthetic polypeptides. There is therefore a strong indication that the same factor is operative in determining the relative stabilities of the α- and β-forms of both proteins and polypeptides. [Nov. 9.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[2] For a review, see von Weimarn, in Alexander's "Colloid Chemistry", 363 (Chem. Catalog Co., Inc., 1932).
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[12] Ambrose, E. J., and Elliott, A., *Proc. Roy. Soc.*, A (in the course of publication).
[13] Bamford, C. H., Hanby, W. E., and Happey, F., *Nature*, **166**, 829 (1950).
[14] Astbury, W. T., and Bell, F. O., *Nature*, **147**, 696 (1941).
[15] Ambrose, E. J., and Elliott, A. (results in course of publication).

# THE GLOMERULAR BORDER IN THE DEVELOPMENT OF THE VERTEBRATE KIDNEY

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IN view of the recently renewed interest in the development of the vertebrate kidney, it is more than ever important that the workers in this field should arrive at and utilize an accepted terminology, both for the purpose of elucidating this complex subject and for the sake of those engaged in teaching advanced zoology. In the course of this communication, we direct attention to a peculiar glomerular structure bordering the kidney in *Sphenodon* and probably in Chelonia, Crocodilia, some birds and possibly man and the sheep. The significance of this border has hitherto been overlooked owing to the application of different meanings to one and the same term.

A typical kidney unit in the primitive condition (Fig. 1) consists of the tubule leading from the duct and opening by a nephrostome into the nephrotome (or its derivative, Bowman's capsule). The nephrotome is connected to the lateral plate mesoderm by the peritoneal funnel, through which the nephrocœle communicates with the splanchnocœle. Projecting into the nephrocœle is a glomerulus which, in such a typical unit, is described as an internal glomerulus. The term 'glomerulus' has a wide connotation, but when prefaced by the words 'external' or 'internal', it applies only to a kidney and its meaning should be very strictly defined. Modifications of the unit occur, and in one type (Fig. 2) the peritoneal funnel widens, loses its ciliation and becomes indistinguishable from the lateral plate. Similarly, the nephrotome and nephrocœle become indistinguishable from lateral plate and splanchnocœle respectively, and the glomerulus now *appears* to protrude into the splanchnocœle, and in this condition is called an 'external glomerulus'. This description of the necessary relationships of an external glomerulus agrees with that given by Fraser[1]. It is obvious that the glomerulus, whether it be external or internal, is separated from the neighbouring cœlomic space by tissue which is nephrotomic in origin, and from this it follows that the surrounding cœlomic space is always to be regarded as nephrocœlic. Thus, the type of the glomerulus is determined by the previous history of the nephrotome. It appears to be equally evident that, in regard to any one kidney unit, an internal and an external glomerulus cannot be co-existent, since the nephrotome of a single kidney unit cannot be both opened out and thus indistinguishable from peritoneum, and separate and distinguishable, at one and the same time. Felix[2] describes the external glomerulus as a separate and independent formation which may co-exist with an internal glomerulus in relation to a single kidney unit in "a pronephros within the vertebrate stem". In his more comprehensive work[3] he does not support this statement. His generalized conception and his terminology are not accepted by present-day zoologists. His diagram has been reproduced in modern anatomical and American text-books.

In the Anamnia, the occurrence of typical kidney units has frequently been described, and there are strong grounds for supposing that atypical units represent fairly simple modifications of the typical unit, and that developmental homologies can be deduced. Similarly, the elements of the units in the anterior part of the developing kidney of *Sphenodon*, Chelonia and Crocodilia may, with reasonable confidence, be homologized with those of a typical kidney unit. In the permanent kidney of reptiles and throughout the developing kidney of birds and mammals the condition is more obscure, so that the homologies of the various parts are open to considerable doubt. We are indebted to Dr. J. Davies for emphasizing (in a letter) the fact that the conception of the typical kidney unit may prove inapplicable to such types.

We have dealt above in detail with the relationships of glomeruli, because an interesting condition of the anterior part of the nephros, which has been overlooked by nearly all investigators owing to the application of different meanings to one and the same term, occurs in some amniotes. The existence has been described in the reptile *Sphenodon*[4] of kidney units in the front of the developing nephros, each consisting of a tubule opening by a large nephrostome into a Bowman's capsule from which a ciliated peritoneal funnel leads into the splanchnocœle (Fig. 3). Projecting into the nephrocœle (in Bowman's capsule) is an internal glomerulus consisting of vascular tissue which is continuous with, and passes over into, an enormous vascular mass bordering the ventral surface of this anterior part of the nephros. This mass was termed the 'glomerular border'; the term was used intentionally to indicate that the structure was not considered to be homologous with external glomeruli *sensu stricto*, as the border is merely that vascular tissue of which some more dorsal portions constitute the individual internal glomeruli; it is separated from the cœlom by peritoneal epithelium. Similarly disposed glomerular tissue occurs commonly in reptiles. Recent authors have reviewed the subject and in so doing have applied the name 'external glomeruli' or 'external glomus' to it[1,5]. The papers reviewed are by Wiedersheim[6], de Walsche[7], and ourselves[4]. In fact, the adjective 'external' was not used by any of these authors. Thus, our intention in the original paper on *Sphenodon* of pointing out the distinction between this structure and an external glomerulus has been overlooked, largely, we realize, because of our failure to define the difference. While we are unable to explain the origin of the glomerular border, we suggest that the condition must result from one of three processes, so that the border consists of: (*a*) primarily internal glomeruli, too large to be contained in the Bowman's capsules, and thus projecting and fusing ventrally; or (*b*) primarily a glomerular border which later, by extension, gives rise to the internal glomeruli; or (*c*) primarily a separate formation from the kidney glomeruli which later become united therewith. In that Davies[5] describes the fusion of internal and so-called external glomeruli in the duck, his work supports the third of these possibilities. We would like to put forward the hypothesis that the glomerular border may be associated with the secretion of cœlomic fluid, as it appears at a time when the extra-embryonal cœlom is extending rapidly, and occurs only in amniotes. There appears to be little reason for supposing that the border has an excretory function in association with the kidney.

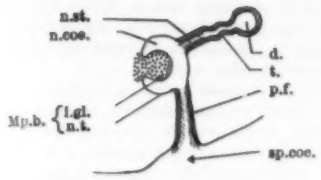


Fig. 1. A typical kidney unit

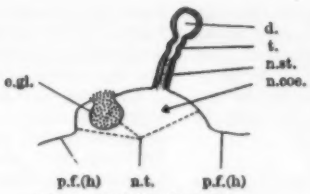


Fig. 2. Relationships of an external glomerulus

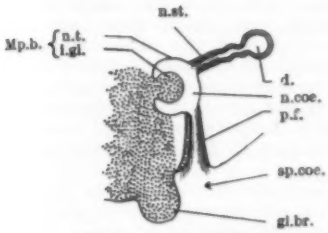


Fig. 3. A unit in *Sphenodon*

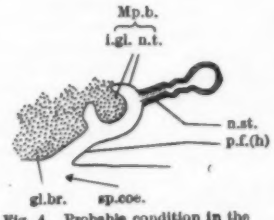


Fig. 4. Probable condition in the chick

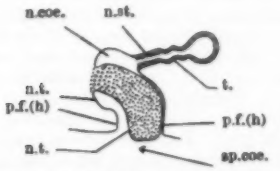


Fig. 5. Another method by which glomerular tissue can, theoretically, project into the splanchnocœle

| | | | |
|---|---|---|---|
| d. | duct | n.st. | nephrostome |
| e.gl. | external glomerulus | n.t. | nephrotome |
| gl.br. | glomerular border | p.f. | peritoneal funnel |
| i.gl. | internal glomerulus | p.f.(h) | homologue of peritoneal funnel |
| Mp.b. | Malpighian body | sp.coe. | splanchnocœle |
| n.coe. | nephrocœle | t. | tubule |

Stippling indicates vascular glomerular tissue.

Although we consider that the term 'external glomerulus' should properly be restricted to examples in which the nephrotome and nephrocœle have opened out into, and become indistinguishable from, lateral plate and splanchnocœle respectively, there are at least three other ways by which, *theoretically*, glomerular tissue can come to lie on the ventral surface of the kidney and yet be derived from the internal glomeruli (see Figs. 3, 4 and 5). It should be borne in mind, however, that the glomerular border may prove to be a separate formation (*vide supra*). Fig. 5 represents a condition of the glomerulus intermediate between typically internal and typically external, and, if it exists, it is difficult to know which, if either, of these two terms should be applied; but it is clearly incorrect to regard the proximal part as internal and the distal as external.

A glomerular border apparently similar to that of *Sphenodon* appears to occur in some birds. Either Fig. 4 or 5 may represent the condition in the chick as described by Sedgwick[4]; in our opinion Fig. 4 represents the more likely interpretation, a condition essentially similar to that of *Sphenodon* (Fig. 3). Sedgwick's account is difficult to follow; Davies[5] has failed to confirm in the duck the findings of Sedgwick in the chick. However, it is noteworthy that Sedgwick wrote (1880): "the external glomerulus (then) in the chick which has hitherto been known as the glomerulus of the head kidney is nothing more than a series of glomeruli of primary Malpighian bodies projecting through the wide openings of the segmental tubes into the body cavity".

The condition of the anterior part of the developing nephros of the duck has recently been described by Davies[5]. Apparently a unit in this region consists (in the terminology based on the typical unit) of a vestigial tubule leading from the duct by a nephrostome into a nephrotome, which latter is invaded by glomerular tissue and forms a Malpighian body. Associated with the kidney units, but not necessarily opening into them, are vestigial peritoneal funnels. The internal glomerulus of the Malpighian body is continuous with, and passes over into, extensive angioblastic tissue on the ventral border of the kidney. At an earlier stage this angioblastic tissue is in the form of a series of anteroposteriorly arranged discrete bodies. The author interprets the bordering angioblastic tissue as a series of external glomeruli, in this respect conforming to his own definition, "a glomerulus is considered to be external when it hangs freely into the peritoneal cavity", but not conforming to that given in this communication. Similarly, the structures we deduce to be vestigial peritoneal funnels are described in the text as nephrostomes and in the illustrations as cœlomic funnels. The term 'cœlomic funnel' for the vestigial cœlomic openings provides, as suggested by Dr. Davies, a suitable description until the homologies of such structures have been elucidated.

From the foregoing, it appears likely that the angioblastic tissue bordering the kidney in the duck, as in *Sphenodon*, does not represent a true external glomerulus but may, again, be regarded as an internal glomerulus too large to be contained in the Malpighian body and extending to incorporate the stroma of the kidney, and thus coming to the surface and projecting into the cœlom ventrally. However, Dr. Davies's observation that "later, internal glomeruli are formed in the same area and become fused with the external glomeruli" indicates the separate origin of glomerular (angioblastic) border and internal glomeruli. He relates the origin of the "external glomeruli" to "the angioblastic activity of the cœlomic epithelium" and thus, in fact, emphasizes the difference between these and true external glomeruli, since these latter must be separated from the neighbouring cœlom by tissue of nephrotomic origin.

The condition in the seagull, judging from a single embryo in our possession, appears to resemble closely that of the duck.

The condition of the anterior part of the developing nephros in the sheep[3] may possibly, in some respects, resemble that of *Sphenodon*. The sheep is stated to possess a para-aortic mass of glomerular tissue which is in continuity with fenestrated glomerular plates. The incomplete knowledge of the development of this para-aortic mass, as well as that of the glomerular border of *Sphenodon*, makes it impossible to reach a final decision; but we think it possible that the para-aortic mass is homologous with the glomerular border as described by us.

To conclude, we have directed attention to the fact that the anterior part of the developing nephros

of some amniotes is characterized during its development by the possession of a glomerular border which projects in the splanchnocœle and is separated from it by peritoneal epithelium. The method of development and the functions of the glomerular border are unknown; the suggestion is made that it may be concerned with secretion of cœlomic fluid.

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## CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE, MYSORE

A MYSORE palace has been converted into a temple of science, to house one of the eleven national laboratories planned by the Council of Scientific and Industrial Research of India. The research centre, thus magnificently housed, concerns itself with food technology. The Industrial Research Planning Committee appointed by the Council some years ago recommended the creation of such a research centre, and early in 1948 steps were taken to set up a Central Food Technological Research Institute. The Mysore Government, headed by the Hon. Mr. K. C. Reddy, came forward at this stage with the offer of the magnificent Cheluvamba mansion with the attached buildings, parks, grounds, etc., covering in all 150 acres of land. This mansion, which was the residence of the late Princess Cheluvajammanni Avaru, the Maharaja's aunt, is a solid and imposing palatial structure beautifully maintained. Mysore, besides, had additional attractions: it has an equable climate, it is situated in close proximity to areas using rice, millet and tubers respectively as major articles of diet, it is the centre of a region growing a large variety of fruit and vegetables, and it has special facilities with regard to water supply and electricity. The other well-known centres of scientific research in this area are the Indian Institute of Science and Sir C. V. Raman's Institute, both at Bangalore. The Nutrition Research Institute at Coonoor is not far away.

The offer was accepted and the gift formally received by Mr. Jawaharlal Nehru, as president of the Council of Scientific and Industrial Research, in December 1948. Dr. V. Subrahmanyan, as assistant director of planning, took in hand the difficult job of converting the mansion into a research institute without permitting the alterations and scientific fittings to destroy the character of the building. By the end of July 1949, the first of the laboratories, the library and the animal house were already functioning.

The main building together with the rear block covers about 110,000 sq. ft. Most of the laboratories, the offices and the library fill the front, while the workshop, machine rooms, stores, etc., are placed in the rear part. The former stables have been appropriately converted into the animal house, which forms a separate block covering about 7,000 sq. ft. Part of this block has been equipped for human metabolism experiments. Monkeys, rabbits and rats are the principal experimental animals used.

The Institute is to do pioneer work in food engineering in India. There is considerable scope for improving the yields from staple foods, thereby reducing the cost of processing, which includes milling, parboiling, making millet rice, manufacture of synthetic rice and of substitute foods from tapioca and other materials. The Institute will investigate problems connected with storage, refrigeration, dehydration, canning and fruit and vegetable preservation, with improving the palatability and digestibility of coarse foods, with the exploration of unfamiliar sources for nutriment, with food sanitation and the detection of adulterants, with the preparing of concentrated foods (including vitamins)—with all problems connected with food industries up to the pilot-plant stage.

Industries connected with food are of vital interest to India. Mr. Nehru, in his message at the inaugural function at Mysore on October 21, reminded people that his Government had laid down a target for food self-sufficiency during the 1951–52 season. Sir Shanti Swarup Bhatnagar, director of scientific and industrial research, pointed out that India's factory production in food industries (flour and rice milling, biscuit making, fruit and vegetable processing, vegetable oils, spirits, etc.) total Rs. 130 crores. Transactions in food imports and exports and in the home market total Rs. 204 crores, and this gives some idea of the vast dimensions of the sector which might be affected by work on food technology. India has a serious problem on hand in the form of its food deficit, but it should be possible to tackle a deficit of 10 per cent by preventing losses during storage caused by fungus, moisture, monkeys, rats and insects—and technological research already has shown the way to accomplish this. Sir Shanti Bhatnagar conveyed to the Hon. Mr. C. Rajagopalachari, who inaugurated the Institute, an assurance given by Dr. V. Subrahmanyan (now director of the Institute) that within a year the Mysore laboratories would be able to make a distinct contribution towards making up the national food deficit. Speaking of the work already being carried on in the Institute, Sir Shanti said that the Biochemistry and Processing Divisions have been concentrating on the production of suitably fortified grains prepared from different starch-bearing materials, pulses and seed-cakes. They are also trying to utilize lucerne in human dietaries—in spite of its high food value, at present it is being used only for animal feeding. Work on the processing and preservation of jack fruit, citrus fruits and cashew fruit, and the standardization of predigested and concentrated protein foods is also making good progress. Sir Shanti directed attention also to work at the Forest Research Institute by Dr. S. Krishna, who has extracted a pectin-like product—a good substitute for starch—from tamarind seed, which at present is only waste material.

The possibilities of processed and synthetic foods were again referred to by Sir S. V. Ramamurthy, who spoke of "synthetic cereals" as "a second line of production". Dr. Subrahmanyan, who had already interested himself in making 'rice' from maize, at the suggestion of Sir S. V. Ramamurthy, turned at Mysore to tapioca and groundnut cake, both these ingredients being available in abundance. Work under Dr. V. Subrahmanyan has shown that 80 per

cent tapioca and 20 per cent groundnut-cake powder is three times as nutritious as rice, and that 75 per cent rice and 25 per cent tapioca is as nutritious as whole rice. Dr. Subrahmanyan has also improved the manufacture of tapioca sago by the addition of 1 per cent of stearic acid, so that the grains no longer stick in cooking. His work has given results contrary to the common belief that tapioca debases rice. The practical value of such work can be immense. "Our production," said Sir S. V. Ramamurthy, "is 60 million tons and our deficit is 6 million tons. This deficit can be made up either from 20 million acres of cereals or only 2 million acres of synthetic cereals."

The inaugural function on October 21 last, which was attended by many distinguished men of science and political leaders, was presided over by His Highness the Maharaja of Mysore. His Highness welcomed the Hon. C. Rajagopalachari and other distinguished guests, and in thanking Mr. Nehru for having accepted for the Institute his gift of the Cheluvamba mansion, His Highness paid a warm tribute to the Indian Government's zeal for progress in scientific research.

The Hon. Mr. C. Rajagopalachari in his address referred to the importance of problems of food technology and recalled how the Marhatta soldiers on their expeditions used to carry flattened rice and roasted pulses in their bags, showing that dehydration was nothing new. He referred also to the importance of subsidiary foods and directed attention to the need for investigations that would eliminate harmful constituents from otherwise edible material and thereby convert it into wholesome food. Mr. Rajagopalachari thanked His Highness and the Mysore Government for the gift of the mansion, as also did Sir Shanti Bhatnagar and Dr. Subrahmanyan.

Among other addresses on the occasion was one by the Deputy Minister for Food and Agriculture, and another by the Vice-Chancellor of the University of Mysore, who stressed the need for simplified cookery and expressed the hope that the Nutrition Research Institute at Coonoor would also gravitate to Mysore.

Sir C. V. Raman paid a tribute to Sir Shanti Bhatnagar's resourcefulness and organizing ability, and rejoiced that men of science are now being given a chance to do things. Speaking of the desperate food situation in India, he said: "We have a vast population in this country living on the land . . . we must allow science to do something for feeding and nourishing this great population".

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# SCIENTIFIC ADVISORY BOARD OF THE INDIAN RESEARCH FUND ASSOCIATION

## ANNUAL REPORT FOR 1949

THE report for 1949 of the Scientific Advisory Board of the Indian Research Fund Association* includes some accounts of research carried out during the year, as well as giving the membership of the Board and its Advisory Committees, a list of papers published on medical research carried out under the auspices of the Indian Research Fund Association during 1949, and the programme of researches and miscellaneous grants recommended to the Governing Body for the year 1950–51.

Besides various inquiries on cholera carried out at the Central Research Institute, Kasauli, the King Institute, Guindy, Madras, and the School of Tropical Medicine, Calcutta, four inquiries on malaria are reported. The Malaria Institute of India, Delhi, was responsible for laboratory and field studies with insecticidal and mosquito-repellent formulations, including both 'Gammexane' and DDT, and at the School of Tropical Medicine, Calcutta, a comparative study was made of the action of paludrine, chloroquine and camoquin in equivalent doses with the view of devising a simple form of mass treatment for people in rural areas. At the Haffkine Institute, Bombay, about forty sulphone derivatives were synthesized, but negative results were obtained with the ten examined for prophylactic activity in the mosquito.

Nutrition researches included studies on pyridoxine and fatty-acid metabolism, on vitamin D, the influence of nutritional factors in liver disease and the influence of dietary protein on the nitrogen balance (at the Nutrition Research Laboratories, Coonoor); the biosynthesis of ascorbic acid, fatty-acid oxidation by the guinea pig and the rat, and the absorption, excretion and effect of iron in foods (University College of Science and Technology, Calcutta); fat metabolism and experimental rickets (Seth G. S. Medical College, Bombay); nutritive value of soya-bean milk and curd (Indian Institute of Science, Bangalore); metabolism of vitamin A (All-India Institute of Hygiene and Public Health, Calcutta); and the biosynthesis of nicotinic acid by germinating pulses and by guinea pigs (Presidency College, Calcutta).

Leprosy inquiries at the School of Tropical Medicine, Calcutta, related to the intramuscular administration of sulphetrone, its concentration in the blood, excretion in urine and the relation between the blood and urinary concentrations and the use of *p*-aminosalicylic acid. The use of sulphetrone and other sulphones in leprosy was also studied at the Government Lady Willingdon Leprosy Sanatorium, Chingleput.

The curative value of aureomycin and chloromycetin in experimental plague infection in mice has been studied at the Haffkine Institute, Bombay. plague researches have included studies of the use of DDT in plague control work in the Nilgiris district under the director of public health, Madras, which have shown that DDT is an extremely effective pulicide which should offer considerable savings on cyanogas, and a preliminary trial with 'Gammexane' has been made. Filariasis inquiries have included, besides screening tests on various compounds, the preparation of thirty new compounds at the B.J. Medical College, Poona, and the Technology Department of the University of Bombay in the chemical part of a study aimed at changing the physical properties of drugs by the introduction of long alkyl chains which confer surface activity. In addition to N-substituted derivatives of stibanilic acid and a range of *p*-alkoxyaniline antimonyl tartrates, derivatives of *p*-aminosalicylic acid have been included in the study.

The work on indigenous drugs at the School of Tropical Medicine, Calcutta, and at the Drug Research Laboratory, Jammu, continued, and at the University College of Science and Technology, Calcutta, an investigation of the action of snake venoms and their constituents on the biochemical activities of tissue

* Report of the Scientific Advisory Board for the Year 1949. Pp. xii+307. (New Delhi: Indian Research Fund Association, 1950.) 1 rupee.

cells made further progress. The report also includes notes on various researches in the field of industrial health, such as environmental factors, the prevalence of byssinosis in the cotton textile industry and sickness absenteeism due to accidents, and on a considerable volume of clinical research under the Clinical Research Advisory Committee.

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## AUTOMATIC COMPUTING ENGINE OF THE NATIONAL PHYSICAL LABORATORY

THE pilot model of the automatic computing engine (A.C.E.), recently demonstrated at the National Physical Laboratory, is a general-purpose automatic electronic digital computer employing mercury-tube ultrasonic delay-lines for the storage of numerical data and instruction sequences, and using a modified Hollerith reproducing-punch for the input and output of these data on punched cards. Calculation proceeds in the binary scale.

The delay-line storage units are of two lengths, the shorter containing 32 binary digits, referred to as comprising one 'word', and the longer containing 1,024 digits, that is, 32 words. The digit interval is 1 μsec.; the recirculation periods of the long and short delay-lines, namely, 32 and 1,024 μsec., are called 'major' and 'minor' cycles, respectively. There are eight long and eight short delay-lines, giving a total capacity of 264 words, equivalent to 264 numbers of nine decimal digits and a sign. Although only a pilot model, the machine is able to deal with many problems of worthwhile complexity in which the numbers of instructions involved and intermediate results to be stored are not too great. For a typical problem of this kind, three or four of the long delay-lines are in use for instructions.

The arithmetic units comprise an adder and a multiplier. The adder is connected in the recirculation path of one of the short delay-lines, known as the 'accumulator', so that any number transferred to the input of the adder is added to the number in the line. It is also provided with a second input through which a number may be subtracted from that in the line. Addition and subtraction thus take 32 μsec., the time occupied by the transfer. The multiplier is connected with three short delay-lines, one to hold the first factor and two connected in series to store the second factor, which is afterwards displaced by the product as multiplication proceeds. The latter two lines are available as an accumulator of two words capacity when not in use for multiplication. Multiplication takes 2 msec., but is automatic as soon as it is started, so that other operations can be carried out during the formation of the product.

In addition to the arithmetical operations, the machine is capable of performing certain logical operations. Two of the short delay-lines are connected with (*a*) a circuit the output of which is the digit 1 when the digits from the lines are both 1, but is 0 otherwise; and (*b*) a circuit the output of which is 1 when the digits from the lines are either (1, 0) or (0, 1), but is 0 when they are either (1, 1) or (0, 0). One of these short lines is also connected with (*c*) a circuit producing 0 when the line produces 1 and conversely, and (*d*) a circuit producing the same output as the line but delayed by one digit interval. The 'logical operations' (*a*) to (*d*) are the only manipulative facilities available internally to the machine besides addition, subtraction, multiplication, delaying the output of a long delay-line by one minor cycle, and selection of the last digit of certain of the short lines. The latter is used chiefly for sign-sensing when negative numbers are represented by complements with respect to $2^{31}$.

All computation and manipulation of data are expressed as an equivalent sequence of simple transfers of words, one or more at a time, from one of 32 possible 'sources' to one of 32 'destinations'. Thus, addition of two numbers is achieved by transferring one of them from its current store-position to the accumulator, thereby displacing the previous word in the accumulator, and then transferring the other number to the additive input of the accumulator. Multiplication is initiated by use of a special destination, the factors having first been transferred to the appropriate short lines. Logical operations are performed by first transferring the operands to the associated short lines, and then transferring the result from the output of the appropriate circuit to the destination at which it is required. These circuits operate continually, whether they are in use as sources or not. The transfers are carried out serially, each being specified by an 'instruction' of one word, five of the digits of which determine the source and five the destination. The assimilation of each instruction by the control circuits occupies one minor cycle (32 μsec.), so that transfers can take place at the maximum rate of 16,000 per sec.

An instruction may be drawn from any of seven long lines and one short line, as specified by three digits of the instruction previously obeyed, and it in turn will determine where the next instruction is to come from. Each instruction also specifies a waiting period of an integral number of minor cycles before the transfer is to begin, and a transfer period for which it is to take place. These numbers lie in the ranges 0–63 and 1–64 respectively, and each is determined by six digits of the instruction word. The instructions are fed continuously to the control circuits from the delay line currently selected; but only the one running in during the last minor cycle of each transfer is accepted and carried out as the next instruction; it will depend upon the wait and transfer numbers of the current instruction. This dependence is modified by the use of a special (and essential) destination called the 'discriminator', when the subsequent course of the computation is to depend upon a result already obtained. When a word composed entirely of zeros is transferred to the discriminator, the next instruction is taken from the normal position in the delay line currently used for instructions; but when a word having some digit 1 is so transferred, the next instruction is taken from the position following the normal one, leading to a different sequence of instructions. All discrimination criteria are capable of expression as the presence or absence of a digit 1 in some word, specially constructed if necessary, so that the above procedure is always adequate.

In addition to the sources and destinations associated with the delay lines and those already mentioned, there are the following: sources of a few useful constant words such as 000 . . . 0, 100 . . . 0, 111 . . . 1; destinations which initiate a read cycle or a punch cycle in the Hollerith equipment; a source indicating (by emitting the word 111 . . . 1) that the input or output cards are in position for

reading or punching a row; and a destination providing an external signal to the operator of the machine (a buzzer).

Reading-in and punching of cards are each carried out at the rate of a hundred cards a minute. Each card has 12 rows, and each row can be punched with one word occupying any 32 columns out of an available 80, as determined by a plugboard. Numbers can be read by the machine from cards punched in standard decimal form, converted to binary form internally by appropriate instruction sequences, and the binary results of calculation reconverted to decimal form and punched, all in the same run.

A number of trial instruction sequences, prepared and used before the multiplier had been installed, included the following:

(1) Determination of the square root of any 31-digit binary number, to 31 digits. 14 instructions; time 60–90 millisec., depending on the number.

(2) Integration of $1/(1 + x^2)$ from 0 to 1 in 256 equal steps by Simpson's Rule. 57 instructions; time 10 sec., 40 millisec. per step.

(3) Integration of Bessel's equation for $J_0(x)$ from 0 to $\frac{1}{4}$ in 4,096 equal steps. 96 instructions; time 52 sec., about 13 millisec. per step.

(4) Determination of the smallest prime factor of any integer less than 4,000,000. This involves up to 1,000 divisions, each of which occupies 6 millisec. for a dividend of 22 binary digits. 31 instructions; time less than 7 sec. With 27 further instructions, preliminary decimal-binary and final binary-decimal conversion can be carried out, the whole taking an insignificantly longer time.

(5) Calculation of the position of a set of light rays after passage through any compound lens having prescribed refractive indices and a given number of spherical surfaces. The surfaces were dealt with in separate runs, all rays being computed at each run. 128 instructions; computing time 1 sec. per ray per surface, which is reduced to 0·2 sec. when the automatic multiplier is used.

The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this article is published by permission of the Director of the Laboratory.

M. WOODGER

## INDUSTRIAL RELATIONS IN CANADA

THE present state of industrial relations in Canada is described in a recent issue of the journal of the Institute of Personnel Management by Miss E. B. Sharpe, deputy director of the Institute (32, No. 311; September–October 1950).

Labour and social legislation are a Provincial and not a Dominion responsibility, although the trend is towards similarity in pattern because big differences in wages and conditions might create unfair competitive conditions between industries located in different Provinces. This trend was stimulated by the emergency powers temporarily vested in the Dominion government during the War, and is encouraged now by annual conferences of representatives from Provincial departments of labour convened to compare the administrative aspects of labour legislation.

The trade union movement is of fairly recent development, and there are still large areas of industry where standards are protected more by legislation on hours, minimum wages, holidays with pay and other working conditions than by collective agreements.

The labour movement of Canada is very closely linked with that of the United States. To-day the movement includes the Trades and Labour Congress of Canada, many of the constituent unions of which are affiliated to the American Federation of Labour; the Canadian Congress of Labour which is similarly linked with the Congress of Industrial Organizations; the International Railway Brotherhoods; and the Catholic Syndicates of Quebec, who feel a closer kinship with French and Belgian unions and are often in conflict with the rest.

In 1947 the Dominion Relations Act was passed which regulates relationships in inter-provincial commerce and services. In essentials this follows the pattern of the Provincial Labour Relations Act, so that an outline of the principal provisions of the Act in Ontario can be accepted as accurate in the main for the country as a whole. The Labour Relations Act includes the following principles:

(1) Collective bargaining shall be compulsory.

(2) The right to strike shall be deferred until after conciliation has been fully explored.

(3) Certain practices on the part of both employer and union are declared to be "unfair".

(4) Members of management down to and including supervisory staff shall be excluded from legal recognition as part of the trade union movement.

Of current issues in industrial relations, the pensions plan has loomed large since it was ruled a legitimate issue of collective bargaining by the U.S. National Labour Relations Board in the steel dispute about a year ago. Two other issues arouse much feeling in Canadian unions and underline the newness and insecurity which the trade unions still feel. One is the demand for a seniority clause in contracts and the other for a union security clause. The former is sought as a protection against arbitrary lay-off or discharge but can also, if not clearly thought out and worded, hamper efficiency by limiting managements' right to promote and transfer for reasons of ability, skill, health and the like; the latter is often sought as a protection against infiltration by rival unions seeking to get a transfer of certification from the "sitting tenant" to themselves. Union security clauses vary from 'closed shop' (where only union members can be engaged and where workers must remain members to keep their jobs) and 'union shop' (where non-members may be engaged but must become members after a certain period) to a variety of maintenance provisions; of these, the 'check-off' (the deduction by the company from an employee's pay to cover his union subscriptions), which is irrevocable for the duration of the contract, is at present being frequently demanded.

In general, it is true to say that the trade union movement in Canada is more accepted and less belligerent than in the United States. The movement is mainly active in collective bargaining and has not interested itself particularly in joint consultation or other forms of participation in management.

An outstanding piece of social legislation is the Workmen's Compensation Act of Ontario, which is followed in pattern, though not quite so liberally in benefits, by the other Provinces. Originating in 1915, the objects of this legislation are to eliminate litigation with all its attendant uncertainties, delays, expense, and frequent bad psychological effects on the injured workman and to give security of pay-

ments and pensions rather than lump sums to the permanently disabled. Administrative costs of the Workmen's Compensation Board run at only five per cent of the levies made on employers, with the result that a high level of benefits can be maintained. There is general satisfaction with the system under which industries are classified according to hazard and each class is liable for the cost of accidents occurring in it.

All questions of eligibility for benefit and amounts of payments are determined by the Workmen's Compensation Board. All accidents must be reported to the Board, which thereafter pays cash benefits ranging, according to disability, up to 75 per cent of average earnings on a maximum of average earnings of 3,000 dollars. In the case of permanent disability, pensions are granted, and, in the case of death, pensions to widows and orphans. In addition, the Board carries the cost of all medical, surgical, hospital and nursing treatment, bills being submitted direct to it. The Board satisfies itself as to the adequacy of the treatment available, and frequently brings injured workmen in from distant parts of the Provinces to Toronto or other cities if specialist services are called for. The Ontario Board has acquired its own nursing and rehabilitation centre near Toronto in 1947, where realistic occupational tests are given to workmen before discharge.

Accident prevention is encouraged by the formation of accident prevention associations of employers in their own class, under the general supervision of the Board. These associations may make safety rules and employ safety inspectors and bring the pressure of public opinion on individual employers whose record is bad and who tend to increase the levy on the industry as a whole.

In order to encourage the employment of the blind, in 1931 an amending Act transferred liability for compensation beyond 50 dollars to an injured blind workman from the Board to the general revenue of the Province, but from that time to the present less than half a dozen claims have been paid in this way, thus bearing out a contention of the Canadian National Institute for the Blind that the blind workman is a safe workman. In return for the benefits of this Act the workman has no right of litigation against the employer or the Board.

Miss Sharpe also describes the work done by personnel officers in industries in Canada.

T. H. Hawkins

## AGRICULTURAL AND HORTICULTURAL RESEARCH STATION, LONG ASHTON, BRISTOL

### ANNUAL REPORT FOR 1949

SOME forty-five papers were published during 1949 by the staff of the Agricultural and Horticultural Research Station (National Fruit and Cider Institute), Long Ashton, Bristol. The annual report of the Station for that year* includes a further twenty-four detailed papers. The practical calibre of the research at Long Ashton is well known, so this large volume of work can only indicate the high efficiency of the Station.

J. D. Cuthbertson and Rita M. Stickley have assessed the yield of cider fruit on bush trees at several centres during 1945–49. The variety Dabinett gave good yields at all the centres with detailed records. G. T. Spinks, who is editor of the report, describes the performance of several new crosses of fruit trees. Pear trees pruned for open centres crop better than those with delayed open centres (E. W. Hobbis and E. Catlow). It seems natural, since fruit-tree roots penetrate the subsoil, to place fertilizers in the lower layers, and J. Tolhurst and C. Bould have initiated work on this question, using a soil injector for the purpose. Prof. T. Wallace, director of the Station, has, with his colleagues C. Bould, D. J. D. Nicholas, J. M. S. Potter and J. A. H. Tolhurst, studied the effects of zinc- and copper-deficiency of fruit trees. Symptoms are well illustrated by photographs, and tentative treatments by branch injection and spraying are being investigated. Interrelations of iron and potassium in the metabolism of the potato plant are discussed by E. W. Jones and E. J. Hewitt, who further discuss the effect of molybdenum-deficiency on some brassica crops.

A group of papers by R. S. Willison, L. H. Luckwill and S. H. Crowdy deals with the importance of virus diseases of fruit trees. These appear to be more severe than is generally recognized, and 'rubbery wood' of apples seems to be the most important. R. J. W. Byrde has found that phenyl mercury chloride (0·0035 per cent), 'Phygon XL' (0·1 per cent) and copper 8-quinolinoleate (0·1 per cent) were effective as June sprays against brown rot of plums. Phenyl mercury chloride and sodium and calcium arsenites were also effective as eradicant fungicides when applied to mummified plums. S. H. Bennett reports high toxicity to *Aphis pomæ* following soil applications of the systemic insecticides *bis*-(dimethylamino) phosphonous anhydride, *bis*-(β-fluoroethoxy) methane and *bis*-(dimethylamino) fluorophosphine oxide. A revision of fruit-spraying programmes, including modern fungicides and insecticides, is given by H. G. H. Kearns and R. W. Marsh, while H. G. H. Kearns and N. G. Morgan describe the automatic spraying of top fruit with a spray mast. They have also designed a light-weight spray nozzle for small- and large-volume spraying.

In the section on cider and fruit juices, L. F. Burroughs and S. W. Challinor continue their fundamental investigations into the role of nitrogen in fermentation. Their third report considers some of the changes in phosphorus associated with the nitrogen. B. T. P. Barker has investigated the yeast fermentation of cider and, with E. J. Hewitt and D. G. D. Nicholas, the molybdenum content of ciders in relation to the incidence of cider sickness. Margaret E. Kieser, A. Pollard and Audrey M. Stone have two papers on the pectic enzyme activity on the clarification of apple juice, and on the effect of manurial treatment on the composition of black currants and their products. Alice Crang and Lorna Kendall have found that temperatures of 150–185° F. (according to the variety) are necessary to inactivate the enzymes which cause browning of plums in bottling. The oxidase system in apples is inactivated between 150–160° F. Finally, G. E. Clothier has some interesting meteorological observations on fluctuations in air temperature at Long Ashton since 1920.

* University of Bristol. Annual Report of the Agricultural and Horticultural Research Station (the National Fruit and Cider Institute), Long Ashton, Bristol, 1949. Pp. 174+8 plates. (Bristol: The University, 1950.) 12s.

# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Liquid-Emulsion Methods in Electron Track Radiography

In an earlier communication[1] reference was made to the possibility of using track radiography as a means of detecting and estimating the content of radioactive isotopes in biological specimens. Since that note was published, further work using a new 'liquid-emulsion' technique has brought us nearer the goal of successful quantitative estimations. The experimental technique employed was briefly as follows.

A suitable culture of *Paramecium caudatum* was washed by centrifuging, and resuspended in a fresh culture medium containing phosphorus-32 at an activity of 0·01 μC./ml. After one hour in this medium, the organisms were centrifuged out and washed three times rapidly with a non-radioactive medium, fixed in 10 per cent formalin and stained with Mayer's 'Haemalum' after photographic processing. The washed suspension of fixed and stained Protozoa was added in darkness to a few drops of freshly melted unhardened Ilford *G*.5 emulsion (previously stored in a refrigerator). The emulsion containing the organisms was poured on to a glass slide, rapidly dried in the dark by a current of air at a relative humidity of approximately 60 per cent, and the preparation was left for 24 hr., at the end of which time the emulsion was developed by the normal low-temperature cycle technique employed for thick emulsions.

In such a preparation the tracks of electrons originating from each organism can readily be seen and, with care, counted. A frequency polygon of the number of electron tracks from 136 individuals is shown in Fig. 1; Fig. 2 shows a few of the tracks at a single focal level in the plane of one organism. The very marked skewness of the distribution is a constant feature of such experiments, and further studies are being made to determine the factors responsible.

The use of liquid emulsion in this work permits a most intimate and permanent contact of specimen and emulsion, not readily obtainable in any other way. The possibility of following the tracks from the organism eliminates any artefacts due to chemical action of the organism on the emulsion[2]. The refrigerated emulsion does not accumulate latent tracks from cosmic ray sources during storage, and will keep fresh for weeks and possibly months without deterioration. Exposure times can thus be adjusted to the tracer content of the organism with a minimum background error, and organisms containing as few as 100 atoms of phosphorus-32 can be employed—with, of course, a correspondingly high statistical uncertainty in their content of phosphorus-32.

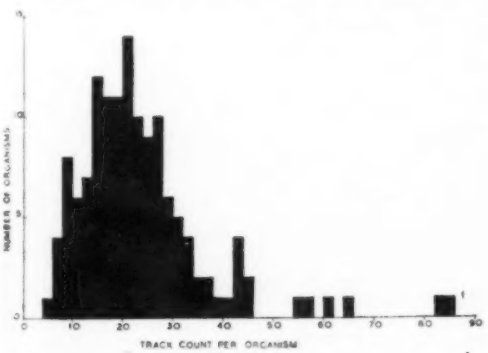


Fig. 1

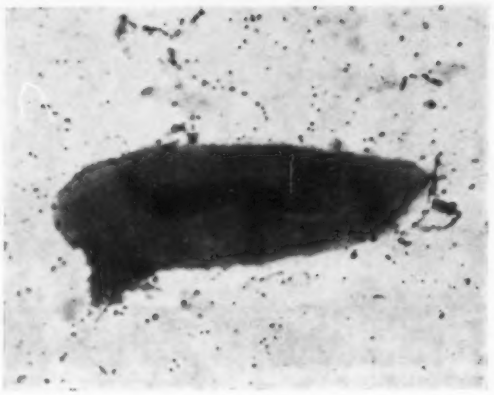

Fig. 2

This work has been carried out with the help of a grant from the Medical Research Council. We are indebted to Mr. C. Waller, of Messrs. Ilford, Ltd., for the samples of *G*.5 emulsion in the unhardened gel form, and to Miss R. Osborn for technical assistance.

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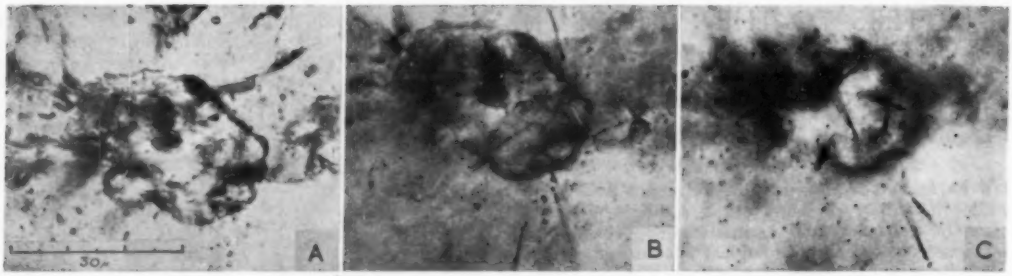
[1] Harris, Sloane and King, *Nature*, **166**, 25 (1950).
[2] Boyd and Board, *Science*, **110**, 586 (1949).

## Radioactivity of Rocks: an Improvement in the Photographic Technique

Existing methods[1-3] for the study of the radioactivity of thin sections of rock using 'Nuclear Research' photographic plates suffer from difficulties in technique. The use of a photographic plate to study the distribution of radioactivity in a thin section of rock entails the removal of the rock section from the emulsion during processing, followed by accurate replacement so that emulsion and section can be examined together. Accurate replacement of the section by mechanical means in its original position relative to the emulsion is obviously difficult, and in addition, since emulsion and thin section must be viewed through the thickness of the glass plate, normal immersion objectives of high resolving power cannot be used. The accurate correlation of alpha-tracks in the emulsion with specific mineral grains or boundaries is also complicated by the presence of an air gap between section and emulsion during exposure, especially in the case of alpha-tracks which may enter the emulsion at small angles of incidence. The error in correlation due to the presence of this air gap may be aggravated if distortion of the emulsion should occur during processing, or if the surface




Photomicrographs of a small mineral grain in a coated-section of De Lank granite showing associated alpha-tracks: taken under a × 95 immersion objective. Exposure time 21 days. *A*, The mineral grain viewed through the emulsion. *B*, Objective focused just above the section-emulsion contact. *C*, Objective focused in the emulsion a few microns above *B*

of the emulsion should need to be cleaned before examination.

Advancement of the method clearly involves the elimination of the air gap between section and emulsion during exposure, and the establishment of an intimate physical relationship between the developed tracks and their source. With this end in view, experiments have been made in which thin sections of Cornish granite of standard 30-micron thickness were coated with thin layers of Ilford *C*2 emulsion in gel form. The thin sections of granite were cut and mounted with Canada balsam on glass slides, using a normal rock-sectioning technique. All excess balsam around the completed sections was carefully removed, and before coating with emulsion the sections were given a final cleaning with ethyl alcohol. The following technique has given satisfactory results. A few c.c. of the gel is liquefied in a small test tube by immersing the lower half of the tube in a water-bath at 45° C. The liquid gel is then carefully poured on the thin section so that the section and a small area of surrounding glass are completely covered. The thickness of the coating can be increased by allowing the liquid gel to cool slightly before pouring, and with a little practice a 50-micron emulsion can be poured quite easily. A stream of filtered air is blown across the newly poured surface for an hour to set the emulsion, after which the coated section is exposed in a lightproof room.

After exposure, and before development, the emulsion is hardened by soaking the coated section in a 3 per cent solution of chrome alum for 15 min. at 16° C. Hardening is followed by a 10-min. wash in running water, after which the plate is developed and fixed as a normal *C*2 'Nuclear Research' plate.

A suitable developer can be made by dissolving 1 gm. of 'Amidol' and 4 gm. anhydrous sodium sulphite in 340 c.c. of distilled water. The plate is developed for 25 min. at 16° C. in this solution, washed for 10 min. in running water, and fixed in a 40 per cent 'hypo' solution until the emulsion is clear. During fixing, the dish is rocked gently to produce a lamellar flow of liquid across the surface of the emulsion. After fixing, the plate is washed for an hour in running water and then left to dry. All coating and processing operations are carried out in a dark room illuminated by a 25-watt lamp shielded by a No. 2 Wratten 'safelight'.

Canada balsam has been described as an unsuitable mounting medium for this work, since it may liberate traces of hydrogen peroxide and, as a result, give rise to fading of the latent images produced by the passage of ionizing particles through the emulsion[4]. Coated sections prepared as described above and exposed for 21 days show no significant fading; but for longer exposures it may be necessary to employ some other medium, especially if emulsions such as the Ilford *G*5 are used in the study of electron phenomena.

A more detailed account of petrographical studies carried out by this method will be published later.

I am indebted to Mr. C. Waller, of the Ilford Research Laboratory, for supplying me with *C*2 emulsion in gel form. In addition, I wish to thank Prof. W. F. Whittard, Dr. F. C. Phillips and Mr. D. T. King for their interest and encouragement, and Mr. E. W. Seavill for assistance with the photomicrographs.

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Dec. 18.

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## Track Autoradiography with Iron-59 and Sulphur-35 with Quantitative Evaluation

Autoradiography has developed quickly during the past year or two, mainly following two different lines. These may be termed 'track autoradiography' and 'contrast autoradiography'. In the latter the exposed grains add to a picture with varying photographic density, which may be estimated or measured quantitatively in different ways. With short exposure it may be possible to count the individual grains as shown by Doniac and Pele[1]; but the normal background fog in the emulsion disturbs the process seriously.

In track autoradiography, every particle emitted makes a track, the starting point of which may be exactly determined. It is also possible—if the film is not over-exposed—to count the individual tracks superimposed over the area of interest. Track autoradiography was developed for α-radiation[2]; but with the aid of highly sensitive nuclear-track plates recently developed[3], it is possible to use the method also for β-radiating isotopes. The fog makes no disturbance, and cosmic ray tracks can be eradicated.

Although track autoradiography has been suggested by some authors, we have only noticed two communications, by Boyd *et al.*[4] and Harris *et al.*[5], dealing with it. We have modified the method to facilitate the counting of individual tracks. It has been developed for application to certain biological problems

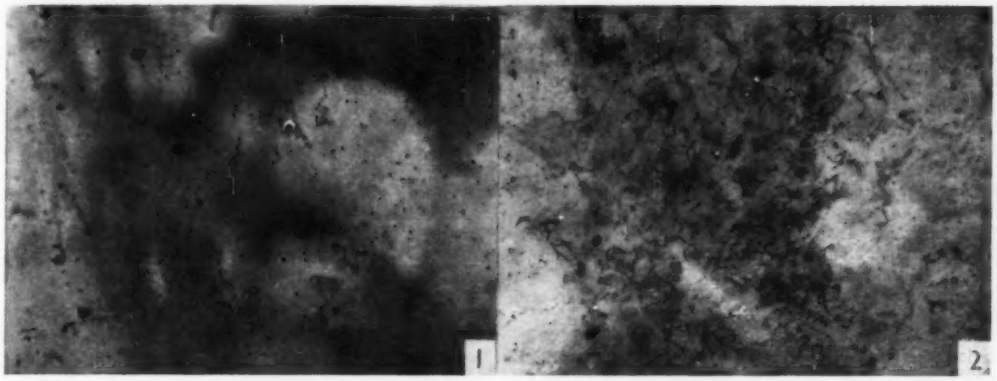

Fig. 1. Stained track autoradiogram of nasal septum obtained with sulphur-35, focused on the photographic emulsion. To the right: the cartilaginous structure with dark intercellular material, where some short intense tracks appear. To the left: the mucous membrane without tracks. × 750

Fig. 2. Unstained track autoradiogram obtained with iron-59 of rat placenta. In the centre there are plenty of long curved tracks superimposed over the yolk sac epithelium. Background tracks are quite few. × 560

which were already being studied in this laboratory in other ways. A more detailed account of this work will appear elsewhere.

The problems of track autoradiography are quite different from those of contrast autoradiography. The ionization of the β-particle increases as its speed is decreased. Thus, a track is obtained built up by grains, which at the end part are close together but at the starting point have greater separation. With high-energy β-particles, a track is formed the starting point of which is rather difficult to determine exactly. Such particles also give long tracks which will mingle into each other and are difficult to follow. The best results are therefore obtained with soft β-radiation.

The isotopes which best fit our problems here are sulphur-35 (maximum energy, 0·169 MeV.) and iron-59 (maximum energy, 0·46 MeV.). These isotopes were given to rats by intraperitoneal injection (as carrier-free sodium sulphate, $7{\cdot}0\times10^6$ counts/min./100 gm. body-weight, and ferroascorbate, $2{\cdot}2\times10^6$ counts/min./100 gm. body-weight, respectively). The animals were killed after 2–100 hr. and different organs were treated by the usual histological technique.

Paraffin sections 10 μ thick were mounted directly on a Kodak *NT4* photographic plate, according to the method of Evans[6]. After de-paraffining, the plates were exposed for 1–2 days, developed, fixed and stained. To get plates with low cosmic-ray background, they were used immediately after delivery from the plant. It was also possible to eradicate all tracks by accelerated fading by treatment at high humidity, a method proposed among others by Albouy[7]. The plates were dried immediately at the start of the exposure so as to have a low starting background. To reduce background tracks further, heavy shielding was used during exposure.

The accompanying photographs show the autoradiograms obtained, with section and emulsion superimposed. The tracks are, of course, much easier to follow with the aid of the microscope. In Fig. 1, the section of tracheal cartilage is stained to show the structures containing chondroitin sulphuric acid. The tracks are quite short and intense, showing clearly a much higher concentration of sulphur-35 than in the neighbouring tissue. These findings are in accordance with the reports of Dziewiatkowski[8], who has used Geiger–Müller counting technique. The few background tracks have a different appearance. A section of this specimen gave only 5 counts/min./cm.² in a Geiger–Müller counter with an efficiency of 10 per cent.

Fig. 2 is an unstained section of a rat placenta with the epithelium of the yolk sac. The tracks are a little longer than those of sulphur-35; but it is possible to count them. This was also done in different areas of the autoradiogram by means of a square net in the eyepiece-diaphragm. Statistical analysis of the counting data showed significant differences in activity obtained over placental sinus, fœtal sinus, yolk-sac epithelium and unexposed background. If the autoradiograms were exposed too long, it was impossible to count the tracks. The exposure time must be determined in accordance with the intensity of the structure of interest. With animals killed at different times after injection, it was possible to follow the path of iron-59 through the placental structures[9]. Geiger–Müller counts of the same section gave very low values, around 25 counts/min./cm.².

Since the sections must not be smaller in area than 1–2 cm.² in order to use the full sensitivity of a Geiger–Müller counter, whereas they may be of any small size in an autoradiogram, it is apparent that track autoradiography by this method is far more sensitive than using a Geiger–Müller counter. The data obtained by autoradiography are also directly correlated to even very small morphological structures, the dimensions of which are about 10 μ. By track counting, data can be obtained which after correction for self-absorption and geometrical efficiency (= 50 per cent) may give the activity also in absolute units.

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## Vertical Distribution of Atmospheric Ozone

On February 25, March 4, March 16 and April 18, 1950, sounding-balloon flights were carried out for the spectrographic determination of the vertical distribution of ozone in the lower stratosphere.

The method[1] consists, essentially, of measuring the steepness of the cut-off which the solar spectrum exhibits at its ultra-violet end near the wave-length 3000 A. Due to the sharp rise of the absorption coefficient of ozone near this wave-length, the slope of the intensity-drop is almost entirely due to atmospheric ozone. Even selective atmospheric extinction due to Rayleigh scattering can be neglected as a contributing factor in the case of balloon flights above an altitude of 10 km.

The instrument with which the four flights were carried out consists of a small, light-weight quartz spectrograph. An automatic mechanism provides for successive exposures of eight minutes duration throughout the flights while the spectrograph is continuously directed at a white magnesium oxide surface mounted below the vertically oriented collimator tube. The slit of the spectrograph is divided into three parts by means of a step filter consisting of three thicknesses of evaporated platinum on a quartz plate. The transparency ratios of the three steps are determined at the wave-lengths in question. Three solar spectra are thus recorded during each exposure, and each with a known attenuation ratio against the others. By determining with a micro-densitometer the wave-lengths at which equal blackening occurs on the three spectra of each exposure, one obtains the slope of the intensity at the ultra-violet end of the solar spectrum. The known absorption coefficients of ozone then furnish for each height an independent determination of the thickness of the atmospheric ozone layer interposed between the spectrograph and the sun. From the measured rate of change of this thickness with altitude, one obtains the vertical distribution of ozone.

The maximum altitudes reached on the four flights were all between 30 and 32 km., as measured with a recording barometer and as verified by theodolite observations from the ground.

The curves in Fig. 1 show in customary units the amounts of ozone which were measured at different heights: the abscissa indicates the thickness of a layer of ozone which would be obtained if all the ozone were taken from an air layer of 1 km. thickness at a given altitude, and if this ozone were then compressed to a pressure of one atmosphere and brought to a temperature of 0° C. Since the stratosphere between 10 and 30 km. is nearly isothermal, the graph is also representative of the partial pressure of ozone.

Fig. 2 shows, on the other hand, the ratio of ozone molecules to air molecules at any given height, computed from the data shown in Fig. 1 on the basis of a constant air temperature of 218° K.

The curves, all taken with the same instrument, show how the vertical distribution of ozone is subject to strong variations both with regard to the shape of the distribution and to the height of the maximum. This was anticipated on the basis of earlier balloon flights[2], and especially on the basis of measurements with the *Umkehr* effect[3]. The total thicknesses of the atmospheric ozone layer were 0·33, 0·40, 0·40 and 0·38 cm. on February 25, March 4, March 16 and April 18, respectively.

The vertical distribution of winds is accurately known to the highest altitudes reached on the first three flights; but no immediate relationship between wind and ozone distribution is apparent. On February 25, the wind averaged 80 km./hr. from the west between 10 and 20 km. altitude, and 30 km./hr. from the east between 20 and 30 km. On March 4, the wind averaged 45 km./hr. from the north-east to north between 10 and 20 km., and 30 km./hr. from the east between 20 and 30 km. On March 16, the wind averaged 80 km./hr. from the west for the range from 10–30 km. The wind distribution on

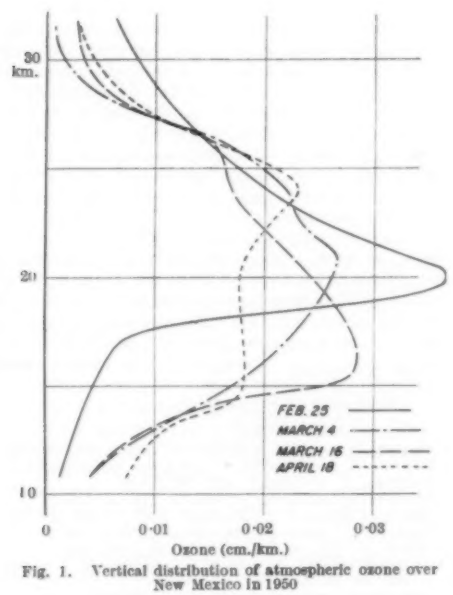


Fig. 1. Vertical distribution of atmospheric ozone over New Mexico in 1950

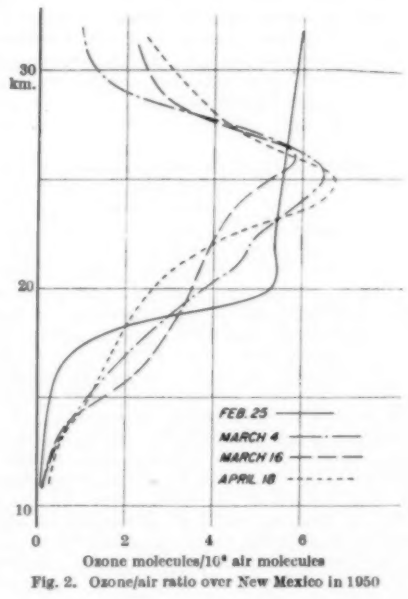


Fig. 2. Ozone/air ratio over New Mexico in 1950

April 18 was probably similar to that encountered on March 16.

The vertical distribution of February 25 is reminiscent of the results from the *Explorer II* balloon flight on November 10, 1935. The almost vertical portion of the curve for February 25 on Fig. 2 suggests that a rather strong mixing process must have been operative at an altitude between 20 and 30 km. to make the ratio between ozone and air so nearly constant.

In view of the apparent existence of pronounced lateral inhomogeneities of the ozone content of the atmosphere at any given instant[4], one must consider the possibility that, due to the non-uniformity of the vertical distribution of wind, portions of the ozone layer with strongly varying ozone-content might be interposed between the balloon and the sun during the course of one balloon flight. The flights of March 16 and April 18 are probably quite free from this source of error, due to the uniform wind distribution with height which was encountered on these two days.

The balloon flights are continuing, and a fuller account will be published elsewhere at a later date. This work has been supported by the Geophysical Research Directorate, Air Force Cambridge Research Laboratories.

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## Protons and the Aurora

ON September 30, 1950, spectrograms were taken simultaneously from Arnprior, Ontario, and Ithaca, New York, separated by 330 km., of an auroral arc located over Arnprior. The Arnprior spectrograph was aimed nearly along the lines of magnetic force, while the Ithaca spectrograph was aimed northward at right angles to the field. Both were aimed at the same part of the arc.

Both exposures clearly show the hydrogen line at 6563 A. On the Ithaca plate it is centred on 6562 A. but broadened to red and violet by about 10 A. The Arnprior spectrum shows the broadening to red of about 10 A., but the violet broadening extends to about 6530. This indicates a shift of the centre of the line of about 15 A. with the maximum violet shift of at least 30 A.

Thus the hydrogen is in motion toward the earth with a mean velocity of 675 km./sec. and maximum velocity of 1,350 km./sec. Since all our previous spectra[1], including those aimed low in the east, show only a broadened hydrogen line, whereas the Arnprior picture shows the violet shift, we must conclude that the hydrogen is coming in from outside in the form of protons.

The broadening on the Ithaca spectrum is due to line-of-sight motion of the scattered atoms or to spiralling around the lines of force.

These results were obtained during a moderate aurora, while a velocity of 3,200 km./sec. was obtained by Meinel[2] during the great aurora of August 18–20, 1950. This suggests a relation between size of the aurora and energy of the protons.

The hydrogen radiations during the aurora are therefore of great geophysical interest. It is suggested that fast spectrographs be aimed at the centre of the corona whenever possible; but useful results can be obtained even when they are aimed 45° away. The hydrogen line appears much stronger than the nitrogen positive bands during the rising phase of the display.

This research was supported in part by the National Geographic Society and by the U.S. Signal Corps under Contract W36—039—*SC*—44518.

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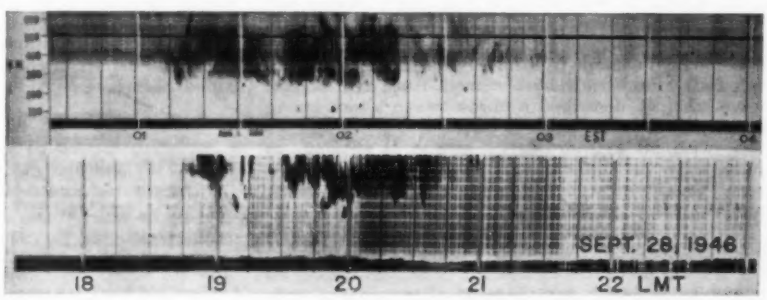
## Reflexion of High Frequencies during Auroral Activity

VERTICAL incidence measurements of the ionosphere at 17·31 Mc./s. usually elicit no reflexions except when meteoric ionization is present, and then the reflexions persist for a minute or two. Recently, however, we have observed enduring reflexions at this frequency during periods of auroral activity. The returns show large slant ranges, probably indicating that the centres of reflexion are at a considerable horizontal distance rather than at great heights. The ionization




Reflexions from aurora borealis. Fig. 1. (above) on 17·31 Mc./s. on August 8, 1950. Fig. 2 (below) on 3·5 Mc./s. on September 28, 1946

responsible for the reflexions must exceed $3 \cdot 7 \times 10^6$ electrons/cm.[3] in order to be observed at this frequency. Somewhat similar echoes from aurora borealis have been reported by Lovell, Clegg and Ellyett[1] using transmissions on 46 Mc./s. Also, ultra-high-frequency long-distance transmission during auroral storms has aroused considerable interest in amateur radio circles[2].

Fig. 1 shows the 17·31-Mc./s. record of August 8, 1950, 0130–0400 E.S.T. at Concord, Massachusetts. The height-markers here are each 20 km. and the total sweep represents 660-km. slant range. The minimum range associated with the auroral pattern is about 220 km. (The horizontal black line at 500 km. is an extraneous marker from some neighbouring equipment.) Local U.S. Weather Bureau observers reported strong visual aurora between 0055 and and 0350 (beginning of dawn). The reflexions in Fig. 1 begin very faintly at 0050, become strong at 0107, and become intermittent at 0235; a faint trace is noticeable at 0344. A number of reflexions due to meteors are evident below the broad auroral pattern, notably the one at 0157 at 100 km., and the one at 0237 at 210 km.

While auroral reflexions on the lower frequencies are commonplace at this latitude, they ordinarily do not yield clear and distinct patterns owing to other complicated background reflexions normally present. Fig. 2 shows one of the clearer recordings received at 3·5 Mc./s. on September 28, 1946. In this figure the height-markers are 15 km. each and the total sweep is 210 km.

Since August 8 we have continued to record 17·31-Mc./s. transmissions with a long sweep, and we have occasionally noticed more reflexions of the type mentioned here, although none so spectacular as those of Fig. 1.

This work is sponsored by the Office of Naval Research under Contract *N*5ori-76, *T. O.* 28.

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Oct. 19.

[1] Lovell, Clegg and Ellyett, *Nature*, **160**, 372 (1947).
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## Action of Trypsin on *Rh*-Positive Human Red Cells

It is well known since the work by Pickles[1], and Morton and Pickles[2], that cholera filtrates and trypsin alter the *Rh*-positive cells with the result that they become agglutinable in saline by anti-*Rh* pure blocking antibodies. On the other hand, Race and Sanger[3] have recently described a chromosome alteration in an individual lacking all antigens at the *Cc* and *Ee* loci, with an extraordinarily strong *D* antigen, as judged by its avidity for anti-*D*. This particular blood was found to be agglutinated by pure blocking anti-*D* diluted in saline.

We have tested the hypothesis that trypsinization would increase the available quantity of agglutinogen (in the widest sense of the word) at the surface of the cell, and that agglutination of trypsinized cells by pure blocking antibodies would be merely a quantitative phenomenon taking place in the zone of optimal proportions between agglutinogens and antibodies.

By absorption experiments we found eventually that trypsinized cells absorbed more anti-*D* than fresh cells, this absorbing power increasing (up to a certain point) when greater amounts of enzyme had been used in the preliminary trypsinization. Absorption was carried out with 1 : 4 vol. of cells (packed) for 1 vol. of serum.

The method of trypsinization used was that described by Dausset and Vidal[4]. A solution of trypsin ('Difco' 1 : 250) in 8·5 per thousand saline is allowed to stand for an hour, then adjusted to *p*H 7·3 with Sörensen's phosphate buffers (20 per cent *M*/15 disodium hydrogen phosphate and 0·5 per cent *M*/15 potassium dihydrogen phosphate). It is mixed with one-third of three-times washed and packed cells, and incubated for one hour in the water-bath at 40° C. During incubation the tubes are frequently shaken. The cells are then washed three times in normal saline.

No hæmolysis was observed, and both the negative controls for agglutination and the morphology of the cells as seen under a high-power microscope were satisfactory.

It is remarkable that absorption of anti-*Rh* sera by trypsinized cells brings down the titres of agglutination in both saline and in albumin, the titre of agglutination in saline with trypsinized cells and also the sensitization as judged by the indirect anti-globulin test. It is therefore most likely to be specific and seems to justify our hypothesis upon the mode of action of trypsin. (Since this communication was submitted, we have received a paper by Wheeler, Luhby and Scholl[5] stating that *D* trypsinized cells absorb more anti-*D* than fresh cells.)

Thus it appeared possible to vary the statistical 'load' of agglutinogen at the surface of the individual cell and to obtain all the degrees of agglutinogenic strength between highly trypsinized and normal cells. I have pointed out recently[6] that such an opportunity affords a means of studying the agglutinogen–agglutinin reaction with both constant antigen and constant antibody techniques. It will be remembered that, using the indirect antiglobulin test, we demonstrated 'prozones' in the antigen excess and the antibody excess ratios, and that the agglutination pattern suggested a linear relationship between the optimal proportions of antigen and antibody. Our conclusion was that 'prozones' could be more satisfactorily explained by an excess of antibody than by the action of a blocking antibody.

The same results have been achieved with anti-*D* blocking sera and *D* trypsinized cells. They suggest that in the case of *Rh*-antibodies also, the 'prozones' and the blocking effect are more satisfactorily explained by a quantitative theory.

A fuller report of these investigations will be published elsewhere.

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Nov. 2.

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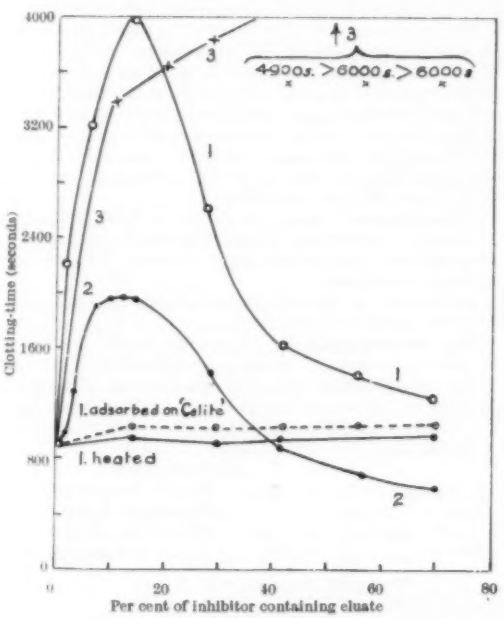
## A Thermolabile Inhibitor of Plasma Coagulation

BARIUM carbonate, used as an adsorbent for stable (platelet-free), oxalated, horse plasma (shaking with 10 mgm./ml. for 30 min. at 0° C.) removes prothrombin with an undialysable, thermolabile substance, destroyed by heating to 60° C. for 30 min. This substance, apparently an albumin, when added to non-activated plasma (without addition of brain thromboplastin), acts as an inhibitor of plasma coagulation.

This natural inhibitor of plasma coagulation can easily be shown to exist in the following way: the adsorbent is washed with saline, dissolved with slight excess of acetic acid (10 per cent) and dialysed in cellulose tubing against normal saline at 5° C. for 48 hr. An excess of acid over barium carbonate is necessary, and the *p*H should be below 3·0 after completely dissolving the carbonate. Prothrombin activity is then destroyed by acidity during dialysis, although some accelerator may remain. The dialysed, dissolved, eluate is isotonic, has a final *p*H of 5·5–5·7 and does not contain barium. The resultant solution (for example, 5·0 ml. from the original 50 ml. of plasma) is tested without thromboplastin in regard to its clot-inhibiting activity against a given amount of horse plasma. Calcium added to the system is dissolved in imidazole buffer[1] and corrects the *p*H to 7·1. All glass used in work with plasma and inhibitor must be coated with organic silica[2]. The accompanying curves illustrate the action of two different crude products each with a diphasic curve of activity.




Action of crude inhibitor preparation from dissolved and dialysed barium carbonate on the coagulation of citrated horse plasma. 1. Inhibitor added in increasing amounts (0·01–0·5) to 0·1 ml. citrated horse plasma; 0·1 of 0·02 *M* calcium chloride, *p*H 7·1. Total volume 0·7 ml. 'Dilution effect' of inhibitor. When heated to 60° C. for 30 min., the inhibiting effect completely disappears. Effect disappears also when inhibitor is adsorbed on 'Celite' (100 mgm./ml., 30 min., 0° C.).

2. Another inhibitor preparation tested on the same plasma. Presence of accelerator evident in higher concentration of inhibitor preparation.

3. Inhibitor from curve 1, after partial purification (without euglobulins). Accelerator removed from inhibitor preparation. System without thromboplastin. All tests were carried out in siliconized vessels at 38° C.

After a partial purification, the inhibitor loses its 'diphasic' character (see graph). Clotting is progressively prolonged as greater amounts of the inhibitor are added. An assay of the partially purified inhibitor shows that 1 ml. of plasma contains less than 2 γ of active protein. The inhibitor can be adsorbed on negatively charged adsorbents, for example, 'Celite' ('Hyflo Super Cel', Johns Manville), kaolin, powdered glass, etc. The inhibitory effect disappears after such adsorption. The same adsorbents shorten the clotting-time of stable plasma (shaking with 10–100 mgm./ml., 30 min., 0° C.) and prothrombin in large amounts can be eluted from them. The acceleration of the clotting time despite loss of adsorbed prothrombin is explained by the excess of free prothrombin in solution as a result of inhibitor being stripped off and held by the adsorbent while free prothrombin comes into solution.

The effects of surface contact, known to accelerate the coagulation of plasma, cannot be detected after adsorption on barium sulphate. The 'dilution effect' of plasma (shortening of the clotting time upon dilution with water or saline) is also absent in a barium-sulphate adsorbed plasma. This can be demonstrated when such a plasma is added in varying amounts to a constant amount of normal plasma, the volume being kept constant.

These experiments show that this inhibitor, while in a complex with prothrombin or a substance related to prothrombin, helps to maintain the fluidity of blood *in vivo*. The agent is completely different from the thermostable 'lipid antithromboplastin' of Tocantins[3] prepared from brain, and it is also different from the pathological globulin of Munro[4] which occurs in certain cases of hæmophilia.

Experiments in an attempt to purify further the inhibitor are in progress. A discussion of the mechanism of prothrombin liberation in the first stage of blood coagulation will be published shortly[5].

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## New Inhibitors of the First Stage of the Blood-clotting Process

IN the course of a study of the non-protein activator(s)[1] of blood coagulation, which always occur(s) in the cephalin fraction of the phospholipids, without being identical with the classical cephalins, two inhibitors of the first stage of the clotting process, namely, glutamic acid and sphingosine, were discovered by means of paper chromatography. Both compounds are completely ineffective in the second stage of the clotting process.

Table 1. Action of Glutamic Acid

Composition of the reaction mixture: 5 drops of plasma, a number of drops of glutamic acid and activators, completed with water to a volume of 9 drops. Gl. = glutamic acid, 3 mgm./ml.; N.P.A. = non-protein activator, 2 mgm./ml.; T.K. = thrombokinase

| No. | Number of drops | | | Clotting time |
|---|---|---|---|---|
| | Gl. | N.P.A. | T.K. | |
| 1 | 0 | — | — | 22 min. 20 sec. |
| 2 | 1 | — | — | 32 min. 00 sec. |
| 3 | 3 | — | — | 210 min. |
| 4 | 4 | — | — | >270 min. |
| 5 | 0 | 1 | — | 4 min. 45 sec. |
| 6 | 1 | 1 | — | 8 min. 30 sec. |
| 7 | 2 | 1 | — | 22 min. 40 sec. |
| 8 | 3 | 1 | — | >50 min. |
| 9 | 0 | — | 1 | 7 min. 00 sec. |
| 10 | 1 | — | 1 | 12 min. 10 sec. |
| 11 | 2 | — | 1 | 30 min. 25 sec. |
| 12 | 3 | — | 1 | >50 min. |

Besides colamine and serine, glutamic acid always occurred among the products of hydrolysis of the cephalin fraction. Chargaff[3] had already discovered a spot on his paper chromatograms of the products of hydrolysis of the monoaminophospholipids, indicating the presence of a substance with a lower $R_F$-value than serine, but he did not identify it. We believe that this was also glutamic acid.

Glutamic acid increases the time of coagulation of chicken plasma and counteracts the action of the non-protein activator(s) as well as the action of thrombokinase (from human placenta); Table 1 shows the results of one of numerous experiments. The action of glutamic acid does not depend upon a possible small change of *p*H.

Sphingosine was found by means of paper chromatography among the products of hydrolysis of the phospholipid of brain, which may have contained sphingomyelin. The inhibition of the coagulation of chicken plasma was studied with samples of sphingosine prepared from sphingomyelin obtained from pig's brain. The inhibition is counteracted by the non-protein activator(s), but not at all, or scarcely, by thrombokinase. Table 2 gives an example of an experiment.

Further addition of thrombokinase in experiments 3, 11 and 4, 12 caused no coagulation within 22 min.; addition of non-protein activator on the contrary caused extremely rapid coagulation in 25 and 55 sec., respectively.

Addition of both sphingosine and non-protein activator to the chicken plasma gives coagulation-times shorter than those obtained with the activator alone (see Table 2, 5, 6). We are unable to explain this surprising fact.

Sphingosine has the same solubility properties as Tocantins's 'anticephalin'[2] but differs from the latter by being thermostable.

Table 2. Action of Sphingosine

Composition of reaction mixtures similar to that in Table 1. Sph. = sphingosine (2·8 mgm./ml.).

| No. | Number of drops | | | Clotting time |
|---|---|---|---|---|
| | Sph. | N.P.A. | T.K. | |
| 1 | 0 | — | — | 43 min. 55 sec. |
| 2 | 1 | — | — | 85 min. 00 sec. |
| 3 | 2 | — | — | >186 min. |
| 4 | 3 | — | — | >186 min. |
| 5 | 0 | 1 | — | 4 min. 00 sec. |
| 6 | 1 | 1 | — | 2 min. 30 sec. |
| 7 | 2 | 1 | — | 3 min. 30 sec. |
| 8 | 3 | 1 | — | 3 min. 30 sec. |
| 9 | 0 | — | 1 | 2 min. 03 sec. |
| 10 | 1 | — | 1 | 3 min. 35 sec. |
| 11 | 2 | — | 1 | >46 min. 30 sec. |
| 12 | 3 | — | 1 | >46 min. 30 sec. |

An inhibitory effect of sphingomyelin was only observed when the sample gave a positive ninhydrin reaction, caused by the presence of sphingosine. Purified samples were completely ineffective in all systems.

Details of this work will be published elsewhere.

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## Adrenocorticotropic Hormone in the Whale

Apart from a verbal communication[1] on the isolation of adrenocorticotropic hormone from whale pituitaries, nothing has to our knowledge been published on the adrenocorticotropic principle of the whale. We therefore wish to report in brief the results of our first investigations into the subject.

For different reasons, we used in our preliminary experiments to be reported here the whole glands (anterior and posterior lobes and the stalk) of fin whale and blue whale in the proportion in which their glands were collected (about 3 : 1). They were worked up according to the procedures[2,3] described for pig and sheep pituitaries, as modified by Fishman[4]. From 1 kgm. of frozen glands 6·25 gm. of 'crude prolactin' was isolated with a content of adrenocorticotropic hormone corresponding to 24 per cent of the Armour *La-l-A* standard, estimated by the ascorbic acid depletion method[5] on rats hypophysectomized by means of the technique used by Smith[6], as modified by Böe[7].

Five grams of 'crude prolactin' yielded 0·40 gm. of adrenocorticotropic hormone with an activity in the depletion test equal to 1·4 times that of the Armour standard.

A detailed report of these and further experiments will be published elsewhere.

The whale glands were collected by the members of the Norwegian Association of Whaling, A/S Thor Dahl, Sandefjord, Svend Foyn Bruun, Tönsberg, Melsom og Melsom, Larvik, and Anders Jahre and Co., A/S, Sandefjord, to whom we wish to express our thanks.

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## Salivary Diastases of the Frog and Toad

ALTHOUGH the presence of diastatic enzymes in the saliva of frogs was originally announced by R. Lépine in 1870 [1] and confirmed by R. J. Junold in 1933 [2], its presence seems so largely to have escaped notice that a fresh investigation using newer techniques is not uncalled for, especially since neither author took the precaution of excluding bacterial enzymes, or made any attempt to determine the precise nature of the reactions involved.

The animals used in the present work were normal adult frogs and toads (no distinction was made as to the sex), which were killed by decapitation using a large pair of bone forceps, regurgitation from the stomach being thereby prevented. Four samples for testing were taken from the mouth of each animal, namely: (1) saline swabbings of the saliva, (2) the whole tongue, (3) scrapings of the mucosa of the palate, (4) the intermaxillary gland. Tissues from several animals were pooled and were incubated at room temperature (*c.* 15° C.) for varying lengths of time. When tested against iodine the red-brown colour characteristic of erythrodextrins appeared in all cases. Bacterial activity was controlled, and it may be safely inferred that such diastatic activity as appeared was not due to bacterial enzymes.

The effect of *p*H on this change from starch to erythrodextrin seems to be nil, since a series incubated at ten different values between 3·5 and 8·0 all gave the brown-red coloration within 30 min. Again, no reducing sugars could be detected in any of the preparations.

When the extracts were incubated at 28° C. no reducing sugars could be detected, even after 18 hr., when starch was used as a substrate; but a positive result was obtained in all cases except the mouth swabbings (which could scarcely have been other than very weak) when glycogen was employed. This complete hydrolysis of glycogen (unlike the starch reaction) is sensitive to changes in *p*H, and can be accomplished only in the range *p*H 4·5–5·5, reduction being complete after 24 hr. under these conditions.

A partition chromatograph, kindly run for us by Dr. J. S. D. Bacon, of the Biochemistry Department of this University, confirmed the above results, and showed that, after 18 hr. incubation at 28° C. with the enzymes contained in pooled tongue and intermaxillary-gland extract, hydrolysis went no further than maltose when starch was the substrate; most of the polysaccharide still remained in the higher dextrin form. With glycogen as substrate a very similar picture was obtained, except that a trace of glucose was also present.

Although the above results point to the presence of a true dextrinogenic salivary enzyme, a further check was provided by testing the activity of similar extracts before and after dialysis. This made it clear that the enzymatic activity of the extracts can be inhibited by the removal of chloride ions and restored by their addition.

Four comparable samples taken from the toad (*Bufo bufo* L.) were incubated for 18 hr. at 28° C. with both starch and glycogen substrates with a result similar to that obtained with the frog material, except that extracts of the tongue and intermaxillary gland of the toad both gave positive results when tested with Benedict solution, and it is presumed that the toad enzyme is more active or more plentiful.

It therefore appears that a true salivary amylase is present in these amphibians, although its functional significance is difficult to understand. The work is being continued with the view of elucidating this problem, as well as the wider questions of the phylogeny of salivary amylases and of the significance of buccal enzymes in general.

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## A New Biometrical Phase Character in Locusts

THE solitary and the swarming phases of the same species of locusts can be distinguished by coloration and by biometrical characters[1]. Among the latter, the ratio $E/F$ of the elytron length ($E$) to the posterior femur length ($F$) has been generally used[2], but no proper statistical investigation of the relative merits of various measurements and ratios exists. Careful measurements of all suitable parts of the body have now been undertaken on samples of the desert locust, *Schistocerca gregaria* (Forsk.), taken from wild populations of a very low density (phase *solitaria*), and from swarms (phase *gregaria*), and the data analysed statistically. None of the twenty direct measurements of body parts proved to be suitable, as the frequency distribution polygons for the two phases overlapped widely. The $E/F$ ratios also showed an overlap which made its use uncertain. Moreover, a comparison of $E$ values in the two extreme phases showed that the elytron-length varied, according to the phase, in an opposite direction in the two sexes, thus:

$$E\ \sigma\ gregaria > E\ \sigma\ solitaria.$$
$$E\ \varphi\ gregaria < E\ \varphi\ solitaria.$$

The fact that $E/F$ in *gregaria* is nevertheless greater than in *solitaria* in both sexes is due to a relatively greater phase variation in the $F$ values, which partly compensates for the irregularity of the variation in $E$.

A number of other ratios have been tested; but all either showed an overlap, or were unsuitable for

| *F/C* | *Nomadacris septemfasciata* Serv. Male | | *Nomadacris septemfasciata* Serv. Female | | *Schistocerca gregaria* Forsk. Male | | *Schistocerca gregaria* Forsk. Female | | *Locusta migratoria migratorioides* R. & F. Male | | *Locusta migratoria migratorioides* R. & F. Female | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sol. | Greg. | Sol. | Greg. | Sol. | Greg. | Sol. | Greg. | Sol. | Greg. | Sol. | Greg. |
| Mean | 3·87 | 3·28 | 3·99 | 3·38 | 3·86 | 3·11 | 3·93 | 3·18 | 3·64 | 2·98 | 3·49 | 2·86 |
| Standard error | ±0·018 | ±0·015 | ±0·018 | ±0·015 | ±0·019 | ±0·009 | ±0·013 | ±0·012 | ±0·010 | ±0·008 | ±0·011 | ±0·007 |
| Standard deviation | ±0·103 | ±0·123 | ±0·107 | ±0·107 | ±0·137 | ±0·094 | ±0·140 | ±0·102 | ±0·106 | ±0·085 | ±0·124 | ±0·077 |
| Difference between means | 0·59 | | 0·61 | | 0·75 | | 0·76 | | 0·66 | | 0·62 | |
| *t* | 24·67 | | 25·36 | | 47·68 | | 35·36 | | 52·23 | | 47·04 | |
| *d.f.* | 102 | | 83 | | 258 | | 215 | | 230 | | 246 | |
| *P* | <0·001 | | <0·001 | | <0·001 | | <0·001 | | <0·001 | | <0·001 | |

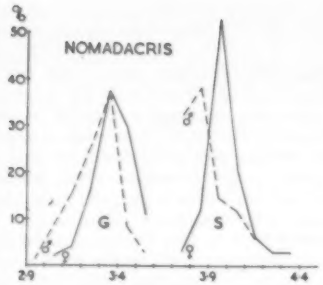


Fig. 1

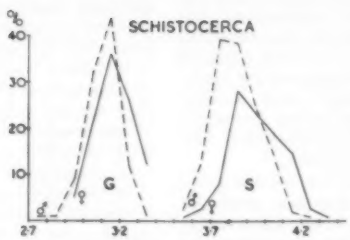


Fig. 2

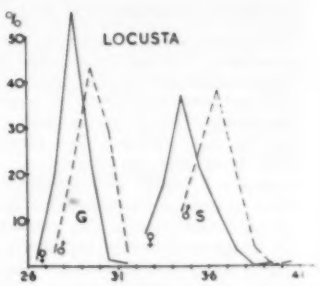


Fig. 3

other reasons, except the ratio between the length of posterior femur ($F$) and the maximum width of the head ($C$). The values of $F$ are lower in both sexes of *gregaria* than in *solitaria*, while the values of $C$ are higher in both sexes of *gregaria*. The ratio $F/C$ shows a highly significant mean difference between phases, regardless of the sex (see table), while the frequency distribution polygons do not overlap (see diagram).

When the ratio $F/C$ was calculated for the African migratory locust, *Locusta migratoria migratorioides* (R. & F.) and the red locust, *Nomadacris septemfasciata* (Serv.), it proved to hold good for them, as well, as can be seen from the table and the frequency distribution polygons. It would be of interest to see whether the ratio $F/C$ is equally suitable for distinguishing the phases in other locusts.

The measurements should be done by carefully calibrated vernier callipers. $F$ is measured as usually recommended[2]; when measuring $C$, the arms of the callipers, kept exactly parallel to the longest dimension of the head, should be passed over the cheeks backwards and forwards, and the reading taken when the arms just fail to pass.

A detailed report will be published in due course.

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## 'Vegetative Hybridization' in the Tomato

The preliminary results of an experiment on 'vegetative hybridization' in the tomato have already been summarized[1]. The progenies from the grafted plants have now been grown, and the purpose of the present communication is to describe more fully the results in the year of grafting and to report on the behaviour of the progenies of the grafted plants.

Gluščenko[2] has suggested that the two characters, shape of leaf and colour of fruit, are especially useful as contrasting types in 'vegetative hybridization' experiments, the leaf character being particularly useful as it can be analysed when the seedling is still in the two-leaf stage. The tomato varieties used in my experiments differ in the two genetically controlled characters mentioned above, the variety Open Air Wonder having potato-type leaves and red fruit, and the variety Golden Sunrise having ordinary tomato leaves (Fig. 1) and yellow fruit. The Russian workers have emphasized two further points, both of which I have followed in my experiments; namely, in the production of a 'vegetative hybrid', the scion should be very young, whereas the stock should be an older and more mature plant; the scion of the grafted plant should be defoliated as fully as possible. Although Wilson and Withner[3] made reciprocal grafts between tomato varieties differing in fruit colour, fruit shape, and fruit size, both stock and scion were of the same age and the scions were not defoliated until after the fruit had set. They also failed to study the progenies of the grafted plants and could therefore not determine the heritable effects of grafting.

In addition to the earlier Russian claims of 'vegetative hybridization', more recently Gluščenko[2] has reported changes in both grafted plants and their progenies. A tomato variety with ordinary tomato leaves was grafted on to a tomato variety with potato-type leaves, and the scion in the year of grafting is described by him as producing both tomato and potato-type leaves. In his illustration of this 'vegetative hybrid', the first two leaves approximate to the potato-type leaf, whereas the leaves developing later appear to be of the ordinary tomato type. As has already been pointed out[1], it is necessary to exercise extreme caution in interpreting such a shoot as a 'vegetative hybrid'. For even in ungrafted plants of an ordinary tomato-leaved variety the first two or first four leaves of some lateral shoots may show an approximation to the potato-type leaf, whereas those developing later are of the ordinary tomato type (Fig. 2). Gluščenko[2] also claims changes in fruit colour in the year of grafting, and the progenies of his grafted plants are described as showing segregation of the contrasting genetic characters. Thus, a potato-type leaved variety was grafted on to a tomato-leaved variety and the seeds from the scion were said to produce plants with potato-type leaves and plants with tomato leaves. Similarly, segregations were reported in the case of fruit colour[2].

In 1949, I successfully grafted eighty tomato plants. In the year of grafting there was no observable influence on the leaf-shape or fruit-colour of either scion or stock[1]. The eighty grafts consisted of 35 plants of Open Air Wonder (scion) grafted on to Golden Sunrise (stock), and 29 of these produced fruit; 28 plants of Golden Sunrise (scion) grafted on to Open Air Wonder (stock), and 21 of these produced fruit; 9 plants of Golden Sunrise (scion) grafted on to Golden Sunrise (stock), and 6 of these produced fruit; and 8 plants of Open Air Wonder (scion) grafted on to Open Air Wonder (stock), and 6 of these produced fruit. The lack of fruit on eighteen scions of the grafted plants was due to damage to the growing points. All flowers were bagged to prevent accidental cross-pollination, and fifteen plants of each variety served as ungrafted controls.

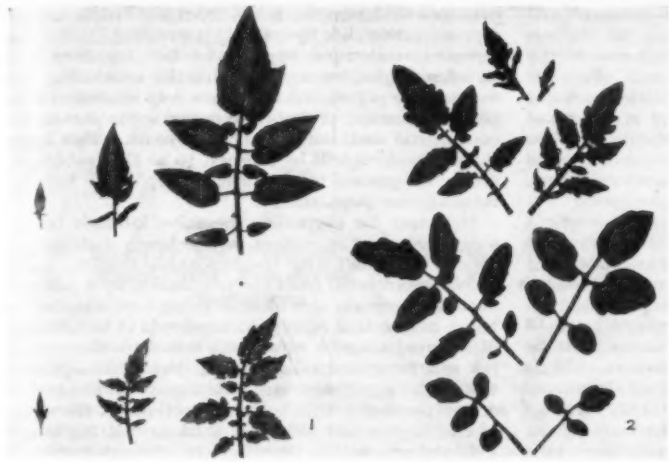


Fig. 1. Potato-type leaves above (Open Air Wonder). Ordinary tomato leaves below (Golden Sunrise). Three stages in the development of each type of leaf are shown

Fig. 2. Successively developing leaves from a lateral shoot of ungrafted Golden Sunrise. The lower leaves approximate to the potato-type leaf, whereas the leaves developed later are of the ordinary tomato type

Similar results were obtained with sixteen more grafts made in 1950.

The seeds of plants grafted in 1949 were sown in 1950, and from these seeds 1,172 plants were grown to maturity in 1950. In addition, twenty plants of each variety served as ungrafted controls. In the progenies of the grafted plants there were no changes in leaf-shape or fruit-colour as the result of intervarietal grafting.

The results of this experiment on intervarietal grafting has thus shown no observable influence on leaf-shape or fruit-colour either in the year of grafting or in the following generation. These results, therefore, do not support the claims of the Russian investigators.

I am indebted to Dr. G. D. H. Bell both for the provision of facilities and his constant interest in the work.

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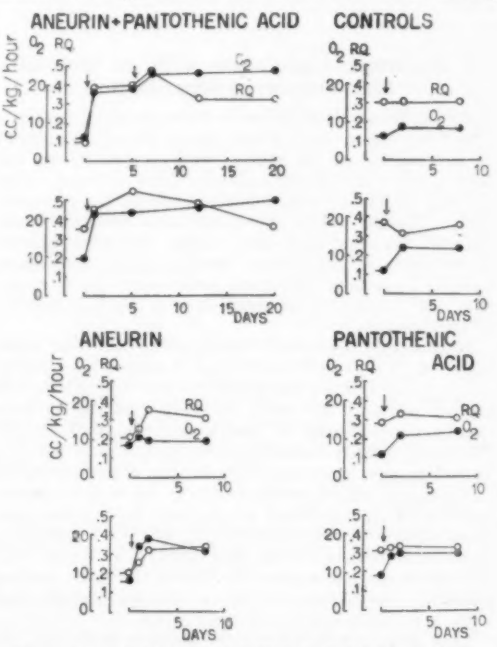
## Pupal Diapause caused by Vitamin Deficiency

In an earlier investigation[1], I established that the pupal diapause of the butterfly *Phalera bucephala* L. is characterized by a very low respiratory quotient, *RQ* 0·1–0·3. During consecutive developmental stages, after incubation by cold, the respiratory quotient rises to correspondingly higher steady levels up to *c.* 0·8 at emergence. During diapause it is too low to be explained by complete combustion of ordinary reserve nutriment of the pupa and must represent a transformation of an oxygen-rich compound into an oxygen-poor compound. A conversion of fatty acids into carbohydrate is assumed, possibly by way of acetate–succinate[2]. The low respiratory quotient has nothing to do with a rhythmic expulsion of carbon dioxide[3]. In the pupæ examined, no fluctuations in the respiratory quotient have been found during prolonged series of measurements, and, furthermore, the carbon dioxide production decreases with increasing temperature. Therefore the low respiratory quotient must be due to a disturbed carbon dioxide production, probably a blocking of the decarboxylating part of the tricarboxylic acid cycle. According to ecological literature, pupal diapause of different insects can be induced by environmental factors prevailing during the larval stage. All these factors mean a direct or indirect restriction of the intake of nourishment: starvation, lowered temperature, kind of food[4], duration of daylight[5], and others. It is therefore not unlikely that this hibernation diapause may be explained by a vitamin deficiency, by a temporary inability to resynthesize some important compounds. Two vitamins form integral parts of enzymes active in the decarboxylating part of the tricarboxylic acid cycle, namely, aneurin in cocarboxylase and pantothenic acid in coenzyme *A*.

For investigating this problem, pupæ in diapause were used of the butterfly *Endromis versicolora* L., which hibernate and during diapause have the same low respiratory quotient, 0·1–0·3, as pupæ of *Phalera bucephala*. Pupæ of *c.* 2 gm. weight were injected with 5 γ aneurin and pantothenic acid. Measurements of respiration were made in the Thunberg




Change in respiration after injection, indicated by an arrow. Each separate diagram represents measurements on one pupa

micro-respirometer[1]. The results are evident from the accompanying diagrams, which show an obvious increase in the respiratory quotient and also in the oxygen consumption. There was no such effect for developing pupæ with a respiratory quotient greater than 0·5. Aneurin injected alone had a somewhat smaller effect, and the effect of pantothenic acid was insignificant. Controls injected with physiological saline also showed an increase in oxygen consumption, but rather a decrease in respiratory quotient.

These results seem to indicate that there is a deficiency especially of aneurin during diapause, thus supporting the assumption mentioned above that diapause is caused by a temporary vitamin deficiency. As the respiratory quotient decreases again later on and the injected pupæ can never be brought to rapid imaginal development, synthesis of vitamin must be connected with other co-operating factors. It is possible that the previously established hormonal control of imaginal development[6] primarily denotes an increased ability for resynthesis not only of the coenzymes mentioned but also of other important enzymes such as apodehydrogenases[7], and cytochromes and cytochromoxidase[6]. Work on this subject is being continued.

This investigation was facilitated by grants from the Scandinavian Insulin Foundation and from the Swedish Research Council for Natural Science.

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## A Molluscan Population with an Unusual Size Frequency-Distribution

The toheroa (*Amphidesma ventricosum*, Gray) is a lamellibranch mollusc which occurs buried to a depth of several inches in sandy beaches mainly on the west coast of the North Island of New Zealand. This species, which is a prized table-delicacy, has generally been believed to confine itself to a strip of beach between low- and high-tide marks. However, abrupt fluctuations in population density which occur from time to time have cast some doubt upon the assumption that the intertidal beach zone is the only habitat of this mollusc.

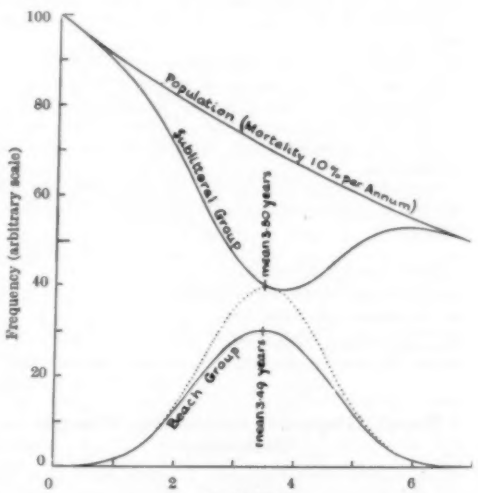
Reasonably consistent estimates of the first seven years of shell growth have been obtained by analysis of length frequency-distributions and by readings of annual rings in the shell, showing that age is very nearly proportional to the square of shell-length. Thus any length frequency-distribution may be converted to age frequency by a simple transformation.

From a series of results taken on all major toheroa beaches of New Zealand in the past three years, and from similar figures collected by M. W. Young (unpublished) between 1933 and 1936, it is found that the age frequency invariably follows the same general pattern, resembling closely a normal distribution with a mode at three or more years.

This distribution obviously departs from the exponential survival curve which might be expected for such a population, and is in itself fairly conclusive evidence that samples taken from the beach are not representative of the total population. As the sampling technique appears to be free from any significant bias, we are left with the conclusion that some of the population is in some way concealed from the investigator, probably living on some part of the continental shelf below low-water mark. This hypothetical section will be referred to as the 'sublittoral group' as opposed to the 'beach group', both together forming the 'population'.

In a test for normality, negative kurtosis but no significant skew is evident on the beach distribution. This is consistent with the hypothesis that the beach group is extracted from the population by a selective process, a certain size of shell being best adapted for beach life, so that age-frequency tends to be normally distributed about a mean which is equivalent to, or (as will be shown) slightly less than, the optimum size. The significant size index may be the surface area of the shell which, being proportional to the square of the length, will also bear a linear relation to age.

If the population were infinite, the age-frequency of the beach group would not be expected to depart significantly from normal. When, however, the population is not a large multiple of the beach group, the greater abstraction nearer the modal point will progressively decrease the relative probability of further abstraction, producing a platykurtic distribution. If, as may be expected, the population is distributed according to the exponential survival curve, it can be shown that the symmetry of the beach group will not be affected, although the position of the mean will be displaced slightly in a negative direction.




A model of the types of distribution which might be expected in the two groups and in the population is given in the accompanying graph. The dotted curve represents the normal distribution that might be found in the beach group if the population were infinite and had equal frequencies at all ages. The beach-group curve is still symmetrical though slightly displaced and is negatively kurtic. The degree of kurtosis and the known magnitude of the beach group (about $10 \times 10^6$ for Muriwai beach) would together be sufficient for an estimate of the population

to be made, though the labour involved in obtaining adequate figures might prove prohibitive.

It is hoped in the future to discover and sample the sublittoral group, and by equating the curves of both groups to the exponential curve to obtain an estimate of population which is independent of the exact nature of the beach distribution.

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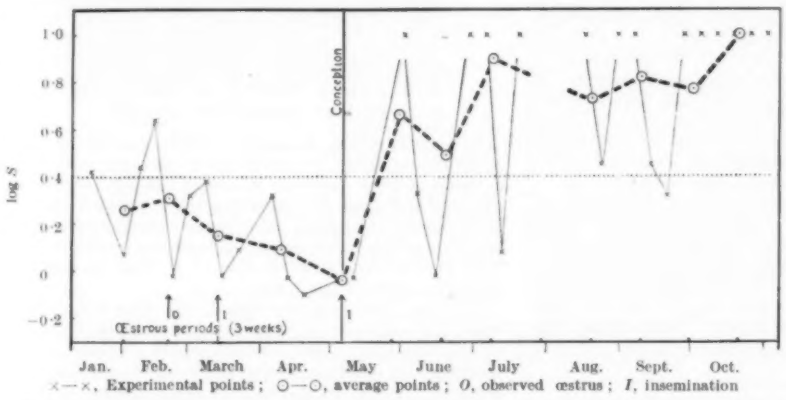
## Bovine Sterility and Pregnancy in Relation to the Rheological Properties of Cervical Secretions

Scott Blair, Cowie and Coppen[1] found that when uterine cervical secretions from the cow were examined in an emptying capillary viscometer the shape of the flow curve changed during pregnancy; but Scott Blair, Cowie and Folley[2] showed that a parameter derived from such curves gave a reliable test for pregnancy only about sixteen weeks after conception. It seemed likely that the test could be improved in four ways: (1) by ensuring that all samples were taken directly from the cervix without vaginal contamination; (2) by using unmixed samples, thereby avoiding disturbance to the structure; (3) by measuring changes in pressure at constant rate of flow rather than extruding at constant pressure and measuring rates, thus largely eliminating accelerations; and (4) by averaging the results of two or three tests.




×—×, Experimental points; ○—○, average points; *O*, observed œstrus; *I*, insemination

In a recent note on experiments on human cervical secretions over the course of a short time, incorporating the first three of these improvements, Clift, Glover and Scott Blair[3] have shown that the slope ($S$) of such curves plotted logarithmically against time gives two maxima and two minima during the menstrual cycle of normal women, the minima corresponding to ovulation and menstruation. Moreover, log $S$ usually reaches values above the non-pregnant maxima quite early in pregnancy. (Data were from about 120 normal women.)

We have now examined secretions taken carefully from the mouth of the cervix from four heifers and two cows over a period of about nine months (242 tests in all) as well as those from four other cows over shorter periods (a further 169 tests). A larger-scale experiment using a more satisfactory viscometer is being started; but, since it will be at least a year before the results of this are available, we feel that the results obtained even on so small a number of animals should be placed on record.

A typical curve is shown in the accompanying graph. Those for four of the remaining animals in the main experiment are very similar. In the non-pregnant animal, sharp minima appear at œstrus. After conception there are still occasional dips, and in some few cases œstrus is actually known to occur. It is clear that a single test would tell us little about the condition of the animal except at œstrus. The broken curve joins points which are the mean of the two or three tests made in each three-week period.

In the case of the five fertile animals in the main experiment and three in the subsidiary experiment, the following points appear. (1) Where the broken line is high, insemination is by no means always successful and must be repeated. Conception generally occurs at the lowest point of this curve. Log $S$ may serve as some indication of the degree of sub-fertility. (2) The broken line lies below the arbitrarily selected value log $S = 0{\cdot}4$ (shown dotted) until soon after conception. It crosses this line between two and about four weeks after conception, after which it remains above during the greater part of pregnancy.

On one occasion the value of log $S$ rose sharply a few weeks after insemination, and an œstrus was missed. When the animal returned to normal œstrus six weeks after insemination, the value of log $S$ had again fallen. This may possibly have corresponded to an early abortion.

The sixth animal in the main experiment and one in the subsidiary experiment were completely sterile heifers and have not conceived after repeated inseminations. They come into œstrus fairly regularly, and the value of log $S$ is then normal for an œstrous secretion. At other times, values are very high: often well above the 0·4-level. The behaviour is quite unlike that of the fertile animals. (The present temporary instrument cannot measure values of log $S$ greater than 1·0, thus introducing an artificial 'ceiling' for the results.)

Whether these preliminary results will lead to a reliable early test for bovine pregnancy (none at present exists), to a useful method for sterility or sub-fertility prognosis and/or to quantitative relationships with hormonal levels can be decided only with a more accurate instrument in a much larger experiment such as we are now planning.

One of us (F. A. G.) is indebted to the Agricultural Research Council for a grant.

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Nov. 13.

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## Scintillations from Thin Films

We have investigated the emission of light pulses from thin films under α-particle bombardment. In all cases, irrespective of the material used, light pulses were observed to be emitted from those films the thickness of which did not exceed the range of the α-particle in the material. The following materials were included in our investigations:

Sulphur, Iodine, Carbon; Nickel Sulphate, Sodium Chromate, Stannous Chloride, Mercuric Iodide; Aluminium, Copper, Tungsten, Iron; Nylon, Glass, Mica, Collodion.

None of these materials is normally considered to be a phosphor, the effect being entirely confined to films which are thin with respect to the α-particle range. The efficiencies of all these films are approximately the same in respect to pulse-height and the number of counts obtained.

In the majority of cases, the substance under investigation was deposited on a 1-mm. quartz slide. This was then mounted over the cathode of a 931 *A* photomultiplier. A strong collimated polonium source was placed about 5 mm. above the slide. Since the pulses from the multiplier are not greater than four times noise, it was found necessary to feed the signals from the multiplier direct into a suitable head amplifier with minimum capacity in the input leads. Owing to the low counting efficiency of these films, a careful and continuous check had to be made on the random count due to noise, etc. This was done by reversing the slide immediately after each reading. A quartz slide was used as it was believed that the radiation was in the ultra-violet.

For purely experimental reasons, nylon films were chosen for a more detailed examination. This included a comparison between the efficiencies of a single nylon film of 0·48 mm. air equivalent, and a zinc sulphide screen. It was found that the counting efficiency of the nylon film was reduced by a factor of 200 and the pulse-height by about 25. A pulse-height distribution was determined (Fig. 1), but, as would be expected, no plateau was obtained.

The effect of film thickness on the phenomena was studied by bombarding a series of similar nylon films. The results are shown in Fig. 2. It appears that, by increasing the nylon by one film thickness more than the α-particle range, the effect disappears. There was also no measurable change in the pulse-heights with increasing thickness. From these considerations, we conclude that the radiation is highly self-absorbent, the radiation length cannot be at most appreciably greater, and may indeed be less, than one film thickness.

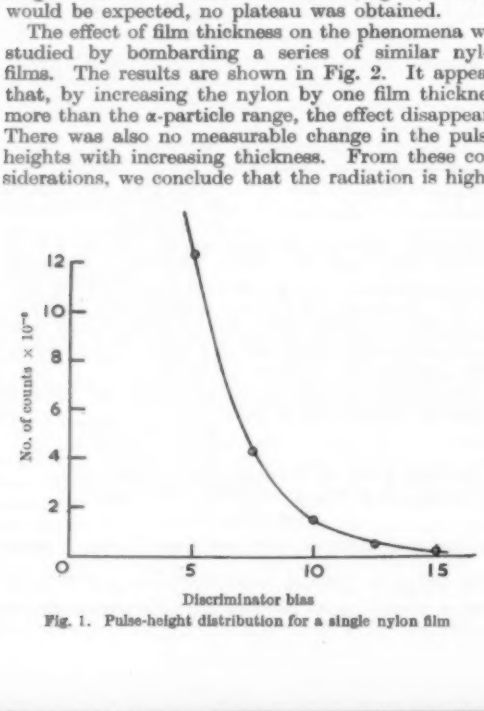


Fig. 1. Pulse-height distribution for a single nylon film

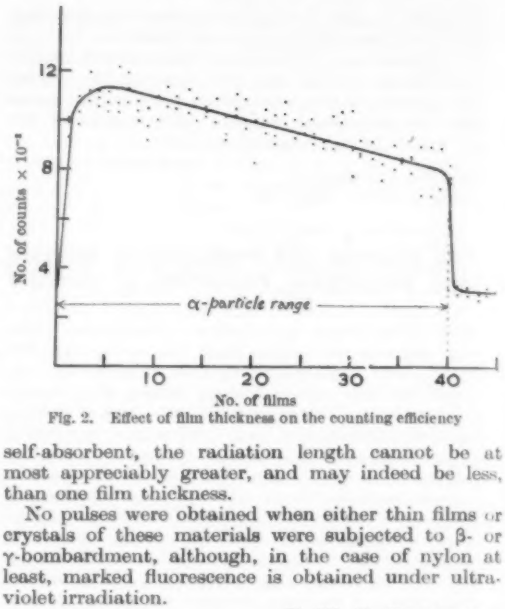


Fig. 2. Effect of film thickness on the counting efficiency

No pulses were obtained when either thin films or crystals of these materials were subjected to β- or γ-bombardment, although, in the case of nylon at least, marked fluorescence is obtained under ultra-violet irradiation.

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## A Sensitive Method of Recording Nuclear Induction Signals

In the detection of nuclear induction signals, it is usual to modulate the main polarizing magnetic field in such a way that its intensity sweeps cyclically over a small region embracing the resonance value[1]. If the amplified signal is fed to a cathode-ray oscilloscope in which the *X*-sweep follows the instantaneous field modulation, it gives rise to a 'blip' at a corresponding part of the trace.

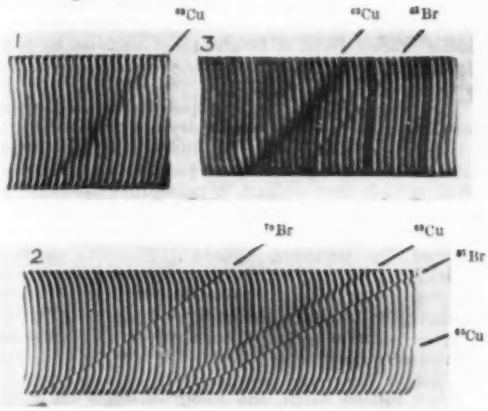
A lower limit is set to visual detection in this way when the signal-level becomes comparable with that of the amplifier noise. In the usual method[2] of extending the sensitivity, the modulation amplitude is reduced to a small fraction of the resonance width, and the output of the detector fed to a 'lock-in' amplifier, followed by a D.C. recorder. If the signal region is traversed slowly, the recorder traces a signal the instantaneous value of which is proportional to the slope of the steady-state nuclear radio-frequency signal. By making the response-time of the output circuit sufficiently long, the signal/noise ratio may be made as high as desired—at the expense of speed of search, and subject to practical limitations of stability.

This method has the disadvantage of using the steady-state response, which, due to thermal relaxation, is intrinsically weaker than that obtainable under suitable transient conditions. Also it requires fairly elaborate means of stabilization and control to give the necessary smooth and slow traverse.

Bloch has pointed out[3] that the signal/noise ratio obtained by oscillographic presentation can be improved by photographic means. If an exposure is

given which lasts over a large number of sweeps, the (random) noise picture is smoothed out into a blurred line, the thickness of which (and hence the effective noise-level) can be controlled by proper selection of film, exposure and development conditions.

We have used a similar technique; but, in order to discriminate also against correlated noise (that is, noise related to, or having its origin in, the field modulation), we have arranged that the camera film is stepped on by a few millimetres after each exposure, while simultaneously the magnetic field intensity is stepped up, or down, by a suitable increment. The signal then appears as a sloping trace on the raster formed by the successive exposures. Each line may represent several hundred forward sweeps of the modulation, the back sweep in each case being blanked out.




Figs. 1–3 represent portions of the spectrum recorded in this way on a spectrometer working at a fixed frequency of 1 Mc./s. In each case, the field intensity decreases from left to right. The copper-63 signal present in each case occurs at an instantaneous field value of 886 gauss. This signal and that of copper-65 (827 gauss) come from the copper wire of the pick-up coil.

On Fig. 1 the correlated noise is particularly prominent; but the signal is clearly distinguished. Fig. 2 shows the typical appearance when moderately strong signals are present. The sample is a solution of lithium bromide. The curvature in the signal lines is due to non-linearity in the field-stepping network.

For optimum detection of a very weak signal, the gain is adjusted so that the lines almost run into one another. Fig. 3 shows a weak signal recorded in this way, the amount of bromine-81 present being 0·035 gm.

For stepping the field we use normal telephone selector switches arranged to control a shunt network across the magnet winding. Stepping of the film is obtained by an identical switch mechanism connected directly to the camera drive. The shutter is left open during a run. An electronic timer controls the impulses to the switches; a typical exposure is 6 sec. per line for a 50 c./s. sweep-frequency. Widely different sweep-frequencies have also been used.

We have experimented also with a continuous shift of the film and field value; but the mechanical problems become more difficult and there appears to be some loss in sensitivity.

We are indebted to Dr. J. S. McPetrie for his interest and encouragement during the work, and to the Chief Scientist, Ministry of Supply, for permission to publish this letter.

I. M. Ross
F. B. Johnson
Signals Research and Development Establishment, Ministry of Supply.

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## Photo-electric Observations of the Scintillation of Stars

In a recent article on the "Scattering of Electromagnetic Waves by Atmospheric Turbulence"[1], Dr. E. C. S. Megaw points out that a study of the scintillation of stars is also a study of the average properties of turbulence in the atmosphere. He reviews the rather scanty observational data that are available on the subject. It is in this connexion that some records of stellar scintillation, that have been made recently with a photo-cell at Dunsink Observatory, and which extend the observed upper frequency-limit of the light fluctuations to about 500 cycles a second, may be of interest.

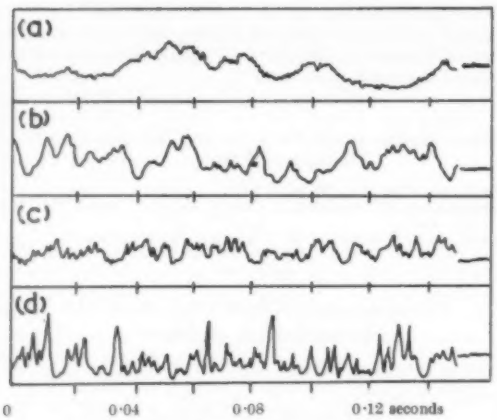
The apparatus consists of a 1*P*21 photo-multiplier tube mounted near the focus of a 15-in. reflecting telescope. The anode current from the cell is fed through a cathode follower to an oscilloscope, where intensity variations give vertical movements to the spot of the cathode-ray tube. Recordings are made photographically on paper moving continuously in the horizontal direction.

The ability of the apparatus to follow the relatively high frequencies encountered has been examined by recording the spot movements when the photo-cell was illuminated by a beam of light which was chopped at uniform intervals by a rotating sector. The response is such that with a paper speed of 36 in. a second, a frequency of well over 1,000 cycles a second is easily resolved. The time constant of the whole apparatus is estimated to be of the order of 100 micro-seconds.

Four specimen traces are shown in the accompanying diagram. Trace (*a*) is of the star Vega when at an elevation of 12°, (*b*) is of Betelgeuse at an elevation of 30° and (*c*) is of Capella high in the sky at a zenith distance of 26°. All three use the full 15-in. aperture of the telescope. The noise-level of the apparatus, as determined with a battery-run standard lamp, is shown on the right of each trace. In each case the zero of intensity is the horizontal line under the trace in question. It will be seen that the star which is lowest in the sky, (*a*), fluctuates with a frequency of about 50 cycles a second, while for Betelgeuse at 30° elevation this frequency has increased to about 150. For the star nearest the zenith, (*c*), the frequency is difficult to estimate, as some of the individual oscillations are so small that they become confused with the noise. Nevertheless, with due regard to this, there may be as many as 400 a second.

The amplitude of the oscillations, expressed as root-mean-square deviations from the mean divided by the mean, are: for (*a*) and (*b*), 40 per cent; (*c*) 25 per cent.

Trace (*a*) was taken on a clear, cold night with a slight northerly wind, and traces (*b*) and (*c*) were




Oscillograms showing stellar scintillation.
(*a*) Vega, 12° elevation; 15 in. aperture.
(*b*) Betelgeuse, 30° elevation; 15 in. aperture.
(*c*) Capella, 64° elevation; 15 in. aperture.
(*d*) Capella, 64° elevation; 4 in. aperture.

taken within half an hour of each other on a night with a moderate westerly wind and a few clouds. So far, our work only covers a small sample of nights. There is, however, every reason for believing that both the root-mean-square amplitude and the frequency vary to some extent from night to night and even during the course of a single night. Nevertheless, the figures quoted appear representative of what has been obtained so far.

If we diminish the aperture of the telescope, the effect is to increase both the amplitude and the frequency. For the stars nearest the horizon the increase in amplitude is proportionately less than for those stars high up, while the reverse appears to be true for frequencies. A single example, with the telescope aperture reduced to four inches, is shown as trace (*d*). It is of the star Capella and was taken within a few minutes of (*c*). It will be seen that the peaks are more prominent than in (*c*), and on a trace of several seconds duration they number up to 500 a second. Also, if due allowance is made for the reduced mean intensity of the star compared with that of (*c*), the peaks are seen to be much more like pulses, rising as they do to four or six times the mean level.

Apart from the usefulness of such observations for the meteorologist, the implications of these intensity variations in astronomical photography and photometry must not be overlooked.

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Jan. 9.

[1] *Nature*, **166**, 1100 (1950).

## Colour Reactions between Clay Minerals and Root Secretions

In the course of experiments designed to test the production by clover roots of a factor inhibitory to nodule formation, plants have been grown in the presence of a wide range of adsorbents including montmorillonite (Wyoming bentonite) and fuller's earth. Both these minerals, besides stimulating the formation of nodules, show strong colour reactions in the neighbourhood of the root.

The experiments in which this was observed were carried out with red clover, growing under bacteriologically controlled conditions, on agar slopes in test-tubes to which small quantities of sterilized bentonite were added at the bottom of the slopes. Normally, the plant cultures were inoculated with an effective strain of nodule bacteria; but the nodule bacteria are not themselves concerned in the reaction since colour is readily developed by uninoculated plants supplied with nitrate. Nitrogen-starved plants (either in uninoculated culture and without added nitrogen or inoculated with ineffective strains of bacteria) develop no colour in the presence of bentonite.

The colour first appears in the bentonite at the root surface after about two weeks growth, and later becomes more pronounced and extends outwards from the root to a distance of some 5 mm. after about three months growth. In acid and neutral media, colour varies from a bright greenish-blue to blue-violet; at an alkaline *p*H an outer brownish-pink zone sometimes appears.

The blue-green bentonite separated from the root darkens to a purple-brown on drying, but changes on acidifying with 10 per cent mineral acid to a bright jade green which is fast on drying. Treatment with alkali (10 per cent sodium or potassium hydroxide or ammonia) instantly discharges the colour, which may be again restored by acidifying. The colour is not affected by reducing agents (formalin, stannous chloride or sodium sulphite) or by oxidizing agents (hydrogen peroxide or potassium chlorate) or by moderate leaching in the cold with water, salt solution or organic solvents (methyl or ethyl alcohol, chloroform, acetone or ether). On heating at 100° C. the colour fades and disappears.

With fuller's earth, the colour changes are not so marked, the clay darkening slightly in the neighbourhood of the root. Only where the secretion is pronounced is a blue-green tint developed. No chemical tests have so far been made with coloured fuller's earth. No colour is found in the presence of acid-washed kaolin, silica gel or asbestos.

Individual clover plants differ considerably in the intensity of the colour induced on bentonite, and the few species of plants so far examined differ qualitatively in the reaction. Oats, rye grass and radish give no colour, flax gives a strong citron-yellow colour, lucerne a faint orange tint and a vetch (*Vicia hirsuta*) marked orange and brown colours.

Colour reactions have been described between bentonite and certain amino-compounds[1,2], and between bentonite and vitamin A and carotenoids[3]; the former is considered to be due to electronic resonance associated with the formation of a 'semiquinone' structure and the latter to salt formation. Failure to elute a coloured material from the bentonite in the rhizosphere in the tests reported above suggests that one or other of these kinds of reactions may be involved.

Work is being undertaken on the identification of the secretion and will be published in due course.

P. S. Nutman

Soil Microbiology Department,
Rothamsted Experimental Station,
Harpenden, Herts.
Oct. 16.

[1] Hendricks, S. B., and Alexander, L. T., *J. Amer. Soc. Agron.*, **32**, 455 (1940).
[2] Hauser, E. A., and Leggett, M. B., *J. Amer. Chem. Soc.*, **62**, 1811 (1940).
[3] Weil Malherbe, H., and Weiss, J., *J. Chem. Soc.*, 2164 (1948).

# FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

## Monday, February 19

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 4.45 p.m.—Dr. C. J. O. R. Morris: "Separation Methods in Biochemistry".* (Further Lectures on February 22 and 26.)

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Is there an Optimum Speed for a Gramophone Record ?" (to be opened by Dr. G. F. Dutton).

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. J. A. Lauwerys: "Herbert Spencer and the Scientific Movement". (Pioneers of English Educational Thought and Practice.)*

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.15 p.m.—Count Eigil Knuth: "The Danish Expedition to Pearyland".

## Tuesday, February 20

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. H. T. Jessop: "Photoelasticity—Determination of the Stresses in Machine Parts".* (Further Lecture on February 27.)

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (in the Chemistry Department, Royal College of Science, Imperial Institute Road, London, S.W.7), at 2.30 p.m.—Dr. A. Carruthers: "Sugar Beet Production".*

BRITISH INSTITUTE OF MANAGEMENT (at Management House, 8 Hill Street, London, W.1), at 5.30 p.m.—Mr. J. J. Gracie: "Organization and Methods in Industry".

INSTITUTE OF PHYSICS, ELECTRONICS GROUP (at 47 Belgrave Square, London, S.W.1), at 5.30 p.m.—Mr. G. F. Nicholson: "Electronics and the M.K.S. System of Units".

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Dr. R. F. Fortune: "Theories of Structure of Social Groups".

INSTITUTE OF PETROLEUM, NORTHERN BRANCH (at the Engineers' Club, Albert Square, Manchester), at 6.30 p.m.—Mr. A. Prizeman: "The Background of Performance Testing of Lubricants".

MANCHESTER GEOGRAPHICAL SOCIETY (in the Geographical Hall, 16 St. Mary's Parsonage, Manchester), at 6.30 p.m.—Prof. T. H. Oliver: "Sicilian Holiday".

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Dr. G. M. Burnett: "Copolymerization".

SHEFFIELD METALLURGICAL ASSOCIATION (at the Grand Hotel, Sheffield), at 7 p.m.—Mr. G. Robinson: "Organization and Use of a Metallurgical Laboratory in a Small Engineering Works".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion on "What we can Learn from the Ocean Bed" (Speakers: Dr. J. D. H. Wiseman, Dr. E. C. Bullard, F.R.S., and Dr. G. E. R. Deacon, F.R.S.).

IRON AND STEEL INSTITUTE (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 8.30 p.m.—Fifth Hatfield Memorial Lecture.

## Wednesday, February 21

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. J. K. S. St. Joseph: "Air Photography and Archæology".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. R. F. Flint: "New Relations in American Pleistocene Stratigraphy".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Discussion on "Recent Work on the Stratosphere" (to be opened by Prof. G. M. B. Dobson, F.R.S., Dr. R. Frith, Sir Charles Normand, Mr. J. S. Sawyer and Dr. F. J. Scrase).

INSTITUTION OF ELECTRICAL ENGINEERS, SUPPLY SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. B. Adkins: "Transient Theory of Synchronous Generators connected to Power Systems".

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY, SOCIAL PHILOSOPHY SECTION (at the Portico Library, Mosley Street, Manchester), at 5.30 p.m.—Mr. Godfrey Armitage: "The Cotton Trade".

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Mr. N. Ingram Hendey: "Littoral Diatoms with special reference to Fouling".

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Mr. C. H. Jackson: "Electronics and Air Transport".

ROYAL STATISTICAL SOCIETY, NORTH-EASTERN GROUP of the INDUSTRIAL APPLICATIONS SECTION (at the Chemical Industries Club, 18 Lovain Place, Newcastle), at 6.30 p.m.—Mr. Hunter: "Statistics and Agricultural Research" and "Commercial Applications of Sampling".

SOCIETY of CHEMICAL INDUSTRY, NEWCASTLE-UPON-TYNE SECTION (joint meeting with the SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, in the New Chemistry Department, King's College, Newcastle-upon-Tyne), at 6.30 p.m.—Dr. E. B. Hughes: "Analytical Control and Investigation in the Food Industry". (Members of the FOOD GROUP are invited.)

INSTITUTE OF FUEL (in the Lecture Hall, Midlands Electricity Board, Stoke-on-Trent), at 7 p.m.—Papers on "Drying in the Pottery Industry".*

INSTITUTE OF INDUSTRIAL ADMINISTRATION, MANCHESTER CENTRE (in the Reynolds Hall, College of Technology, Manchester), at 7 p.m.—Mr. E. Meigh: "Management—Empirical or Professional".

## Thursday, February 22

FAUNA PRESERVATION SOCIETY (at the Zoological Society of London, Regent's Park, London, N.W.8), at 4.15 p.m.—General Meeting.

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. E. K. Rideal, F.R.S., and Mr. R. Roberts: "The Photochemistry of Native Proteins"; Mr. D. Downs, Mr. A. D. Walsh and Mr. R. W. Wheeler: "A Study of the Reactions that lead to 'Knock' in the Spark Ignition Engine".

LINNEAN SOCIETY OF LONDON (joint meeting with the SYSTEMATICS ASSOCIATION, at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Discussion on "Taxonomic Treatment of Biological Races" (to be opened by Mr. B. L. Burtt, Dr. C. A. Hoare, F.R.S., Dr. R. W. G. Dennis and Mr. P. F. Mattingly).

PHYSICAL SOCIETY, ACOUSTICS GROUP (in the Henry Jarvis Hall, Royal Institute of British Architects, 66 Portland Place, London, W.1), at 5 p.m.—Dr. W. H. George: "The Acoustics of the Piano".

UNIVERSITY OF LONDON (in the Chemistry Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. R. F. Flint: "Dating Late-Pleistocene Events through Radiocarbon".*

INSTITUTE OF METALS, BIRMINGHAM SECTION (at the James Watt Memorial Institute, Great Charles Street, Birmingham), at 6.30 p.m.—Dr. J. M. Robertson: "Metals for Gas Turbines".

## Friday, February 23

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Geophysical Discussion on "Winds and Turbulence in the Ionosphere".

BEDSON CLUB (in Lecture Theatre I, Chemistry Department, King's College, Newcastle-upon-Tyne), at 5.30 p.m.—Prof. A. Robertson, F.R.S.: "Some Recent Advances in the Chemistry of Mould Products".

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Discussion on "Fatigue Tests".

PHYSICAL SOCIETY (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5.30 p.m.—Dr. W. D. Wright: "Modern Problems in Colorimetry". (17th Thomas Young Oration.)

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Mr. A. S. Gladwin: "Some Aspects of Pulse Modulation Communication Systems".* (Further Lecture on March 9.)

ROYAL AERONAUTICAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Monsieur Maurice Roy: "Power versus Weight in Aviation". (Fourth Louis Bleriot Lecture.)

MANCHESTER STATISTICAL SOCIETY, INDUSTRIAL GROUP (at the Albert Hall, Peter Street, Manchester), at 6.45 p.m.—Mr. E. J. M. Rosenthal: "An Introduction to Sequential Analysis".

PLASTICS INSTITUTE (at the Engineers' Club, Albert Square, Manchester), at 6.45 p.m.—Mr. J. L. Daniels: "Developments in Plastic Moulding Plant, with particular reference to Automatic Operation".

ROYAL PHOTOGRAPHIC SOCIETY, KINEMATOGRAPH SECTION (at 16 Prince's Gate, London, S.W.7), at 7 p.m.—Mr. Norman Leevers: "Magnetic Recording in Kinematography".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Miss Dorothy Sayers: "Dante's View of the Cosmos".

## Saturday, February 24

BRITISH PSYCHOLOGICAL SOCIETY, MEDICAL SECTION (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 2.30 p.m.—Dr. H. V. Dicks: "Recent Impressions of Russian Psychology".

INSTITUTION OF CHEMICAL ENGINEERS, MIDLAND BRANCH (in the Latin Theatre, The University, Edmund Street, Birmingham), at 3 p.m.—Mr. C. T. Meiklejohn and Mr. P. D. Coppock: "The Behaviour of Gas Bubbles in relation to Mass Transfer".

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# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT FOR RESEARCH in certain aspects of the nature of the intestinal flora of the ruminant, the pig and of small experimental animals, and its role in nutrition—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, Berks (February 24).

ASSISTANT MASTER to teach general science to matriculation standard, at the General Wingate School, Addis Ababa, Ethiopia—The Director, Personnel Department, British Council, 65 Davies Street, London, W.1 (February 24).

ASSISTANT MASTERS to take (*a*) Senior Chemistry and Biology, (*b*) Senior Physics and Mathematics, (*c*) Middle School Chemistry and Biology, (*d*) Middle School Physics and Mathematics, at Victoria College, Cairo—The Secretary, Victoria College Council of Management, c/o Education Division, British Council, 65 Davies Street, London, W.1 (February 24).

EDUCATIONAL PSYCHOLOGIST (with honours degree in psychology or equivalent, clinical training and/or experience and varied teaching experience) at Harrow Child Guidance Centre—The District Education Officer, Education Offices, High Street, Harrow-on-the-Hill, Middx. (February 24).

EDUCATIONAL PSYCHOLOGIST (woman, with an honours or research degree in psychology) in the Child Guidance Service—The Chief Education Officer, County Education Office, Trull Road, Taunton (February 24).

STATISTICIAN in the Department of Agriculture on the staff of the Oil Palm Research Station at Benin, Nigeria—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1 (February 24).

ASSISTANT MASTERS (with university degrees or equivalent qualifications) IN MATHEMATICS, PHYSICS OR ENGINEERING (electrical or mechanical), at H.M. Dockyard Schools—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 3474 (February 28).

DIRECTOR OF THE NEW HORTICULTURAL CENTRE of the Ministry of Agriculture at Loughall, Co. Armagh—The Secretary, Civil Service Commission, Stormont, Belfast (February 28).

LECTURER IN AGRICULTURAL ECONOMICS in the Department of Political Economy—The Secretary of University Court, The University, Glasgow (February 28).

LECTURER IN CHEMISTRY (with a B.Sc. degree, with first- or second-class honours or equivalent, with specialization in the field of organic chemistry and/or biochemistry) at the University of Tasmania and Hobart Technical College—The Agent-General for Tasmania, 457 Strand, London, W.C.2, or The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (February 28).

PLANT BREEDERS in the Grass Breeding and Cereal Breeding Departments—The Registrar, Welsh Plant Breeding Station, University College of Wales, Aberystwyth (February 28).

SCIENTIFIC OFFICERS (with first- or second-class honours degrees or equivalent qualifications in physics or electrical engineering with some experience on aerial problems, radio receivers and small transmitters for airborne or mobile use) at an R.A.F. Signals Experimental Establishment in Norfolk—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.32/51A (February 28).

SENIOR ASSISTANT ANALYST for County Laboratory—The County Medical Officer of Health, County Offices, Preston (February 28).

ADMIRALTY ARCHIVIST—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 3461 (March 1).

HOOVER POSTGRADUATE STUDENTSHIP IN PHYSICS, CHEMISTRY, ENGINEERING, or an allied subject—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 1).

LECTURER IN CHEMISTRY in the United College, St. Andrews—The Secretary, The University, St. Andrews (March 1).

METALLURGIST or CHEMIST (Scientific Officer grade) with a sound knowledge of inorganic chemistry, to work in the field of extraction of pure rare metals, in the Ministry of Supply Division of Atomic Energy (Production), Windscale, Sellafield, Cumberland—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.54/51A (March 2).

SENIOR SCIENTIFIC OFFICER (Ref. A.23/51A) to lead a group of physicists and engineers studying the effects of tropical conditions on Service materials and equipment, a SCIENTIFIC OFFICER (Ref. F.53/51A) to work on analytical or biochemical investigations in deterioration of equipment under tropical conditions, and EXPERIMENTAL OFFICERS or ASSISTANT EXPERIMENTAL OFFICERS (Ref. G.18/51A) to assist in the work described above, at the Tropical Testing Establishment, Port Harcourt, Nigeria—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (March 2).

BIOCHEMIST and a MICROBIOLOGIST in the Cider and Fruit Juices Section at the Long Ashton Research Station—The Registrar and Secretary, The University, Bristol (March 3).

DEPUTY LECTURER IN GEOLOGY—The Professor of Geology, Trinity College, Dublin (March 3).

LECTURER IN GEOLOGY—The Registrar, University College, Leicester (March 3).

LECTURER IN MATHEMATICS, a LECTURER IN TELECOMMUNICATIONS and a LECTURER IN CHEMISTRY—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (March 3).

SENIOR EXPERIMENTAL OFFICERS, EXPERIMENTAL OFFICERS and ASSISTANT EXPERIMENTAL OFFICERS at Admiralty Experimental Establishments in the vicinity of London, Baldock, Greenock, Haslemere, Portsmouth, Rosyth and Weymouth: MECHANICAL ENGINEERS (Ref. C.632/50A) with research and development experience in light mechanisms, ELECTRICAL ENGINEERS (Ref. D.366/50A) with experience in telecommunications, radar, electronics or light electrical mechanisms, PHYSICISTS (Ref. A.335/50A) interested in general physical problems, electronics or acoustics—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (March 3).

SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS at Admiralty Experimental Establishments in the vicinity of London, Baldock, Greenock, Haslemere, Portsmouth, Rosyth and Weymouth: PHYSICISTS (Ref. A.336/50A) capable of undertaking research or development in general physical problems, electronics, acoustics or thermodynamics, ELECTRICAL ENGINEERS (Ref. D.367/50A) qualified to undertake research, development or design in telecommunications, radar, electronics, instrumentation or light electrical mechanisms, MECHANICAL ENGINEERS (Ref. C.631/50A) capable of design, development or research work in light mechanisms, structures or hydrodynamics—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (March 3).

ASSISTANT IN POMOLOGY at the Long Ashton Research Station—The Secretary, The University, Bristol (March 4).

LECTURER or ASSISTANT LECTURER IN THE DEPARTMENT OF TEXTILE INDUSTRIES—The Registrar, College of Technology, Manchester 1 (March 5).

SCHOLARSHIPS by Governments and Universities in Austria, Belgium, Brazil, Denmark, Finland, France, Germany, Italy, The Netherlands, Norway, Persia, Portugal, Spain, Sweden and Switzerland—The British Council, 65 Davies Street, London, W.1 (March 7).

ASSISTANT LECTURER IN MATHEMATICS at the Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square London, W.C.1 (March 10).

CHIEF POLLUTION OFFICER (with university degree or equivalent qualifications in chemistry and/or biology, and practical experience of, and experience in, sewage purification and the disposal of industrial wastes)—The Clerk to the Northumberland and Tyneside River Board, 4–5 St. Nicholas Buildings, Newcastle-upon-Tyne 1 (March 10).

EDUCATIONAL PSYCHOLOGIST at the Belfast Child Guidance Clinic—The Executive Officer, Royal Belfast Hospital for Sick Children, Falls Road, Belfast (March 10).

LECTURER IN PHYSICS—The Registrar, King's College, Newcastle-upon-Tyne (March 10).

RESEARCH FELLOWSHIP IN SCIENCE—The Secretary, The University, 38 North Bailey, Durham (March 10).

RESEARCH OFFICERS (Biologists) in the Division of Fisheries: (Ref. No. 3174) Appointee will be stationed initially at headquarters at Cronulla, N.S.W., but will be required later to work in Western Australia and may be required to serve, at any time, on one of the Fisheries Research Vessels of the Division; (Ref. No. 3265) Appointee will have his headquarters at Cronulla, but will be required to serve on the Fisheries Research Vessels of the Division—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (March 10).

SCIENTIFIC TECHNOLOGIST, Grade II, in the Scientific Department at London headquarters—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, endorsed TT/295 (March 10).

LECTURER (with special interest or experience in the study of viruses) IN THE DEPARTMENT OF BACTERIOLOGY—The Registrar, The University, Leeds 2 (March 12).

ENGINEERS for development and research work in electro-mechanical engineering, and METALLURGISTS for applied research and investigations on industrial problems, ferrous and non-ferrous materials, etc., in the Dominion Physical Laboratory at Lower Hutt, New Zealand—The High Commissioner for New Zealand, 415 Strand, London, W.C.2 (March 17).

SPEECH THERAPISTS (female), School Medical Service, New South Wales Department of Public Health—The Agent-General for New South Wales, 56–57 Strand, London, W.C.2 (March 19).

TEACHERS (Special Grade) OF MARINE ENGINEERING in the Department of Technical Education of New South Wales—The Agent-General for New South Wales, 56–57 Strand, London, W.C.2 (March 19).

LECTURER IN ELECTRICAL ENGINEERING at the University of the Witwatersrand, Johannesburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (March 21).

CHIEF RADIO ENGINEER, Airways Division, Civil Aviation Branch of Air Department, New Zealand—The High Commissioner for New Zealand, 415 Strand, London, W.C.2 (March 31).

LECTURER IN AERODYNAMICS—The Secretary of University Court, The University, Glasgow (March 31).

AERONAUTICAL AND MECHANICAL ENGINEERS (Scientific Officer grade) in Ministry of Supply research and development establishments mainly in the south of England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.653/50A.

LECTURER IN RAYON TECHNOLOGY at Bradford Technical College—The Director of Education, Town Hall, Bradford.

LECTURER, and an ASSISTANT LECTURER AND DEMONSTRATOR, in THE DEPARTMENT OF CHEMISTRY—The Secretary, King's College of Household and Social Science, Campden Hill Road, London, W.8.

METALLURGISTS (Ref. MB/1/2) to (*a*) interpret metallurgical research information for the use of design engineers, (*b*) advise design engineers on materials of construction, (*c*) assess engineers' requirements with the object of initiating metallurgical development work either internally or extramurally, and a METALLURGIST (Ref. MB/3) to (*a*) interpret metallurgical research and development information on fissionable materials, for use by design engineers and production personnel, (*b*) assess engineers' requirements and production experience with the object of initiating metallurgical research and development on processes for the production of fissionable materials, in the Department of Metallurgy, Risley—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting the appropriate Ref. No.

NUTRITION OFFICER (woman) to investigate and advise on nutrition problems and to instruct local personnel, H.M. Colonial Service, Mauritius—The Director of Recruitment (Colonial Service), Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. 3/27321/2/50.

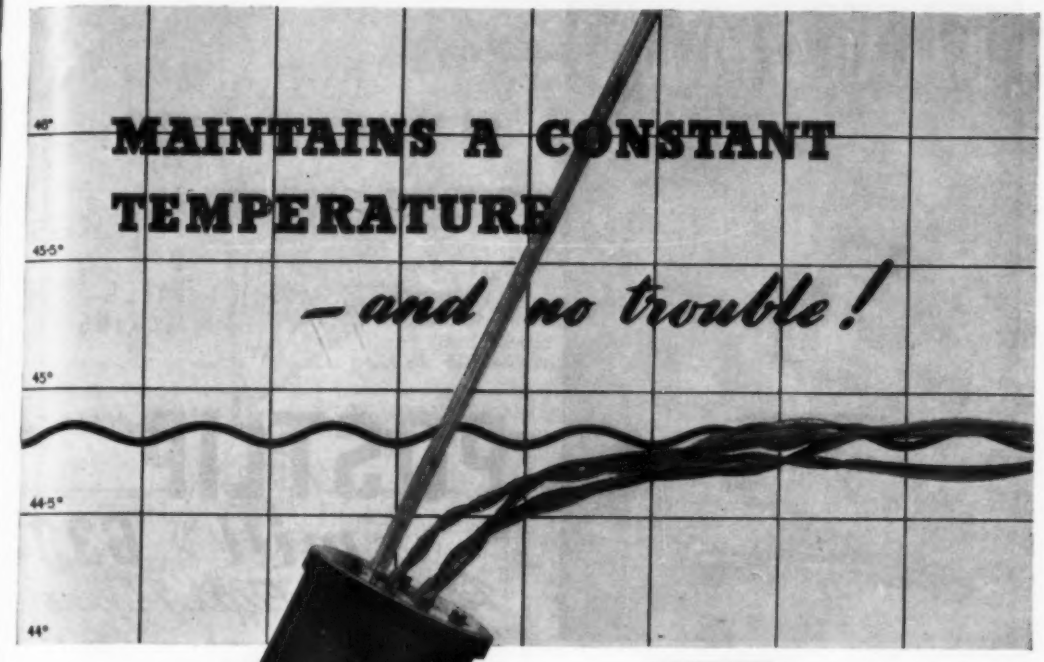
PHYSICIST with good honours degree and some experience of research in physics (excluding electronics)—The Director, British Scientific Instrument Research Association, Sira, Southill, Elmstead Woods, Chislehurst, Kent.

PHYSICISTS and ELECTRONICS ENGINEERS (Experimental Officer grade) in Ministry of Supply research and development establishments mainly in the south of England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.360/50A.

RESEARCH and DEVELOPMENT CHEMISTS by the Division of Atomic Energy (Production), Ministry of Supply Factory, Capenhurst, Chester, to take charge of and to undertake chemical research and development work—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS in various Government departments and for a wide range of scientific research and development in most of the major fields of fundamental and applied science—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3399.

STATISTICIAN to take charge of the Principal Department of Statistics, Government of Iraq—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.27389.E.

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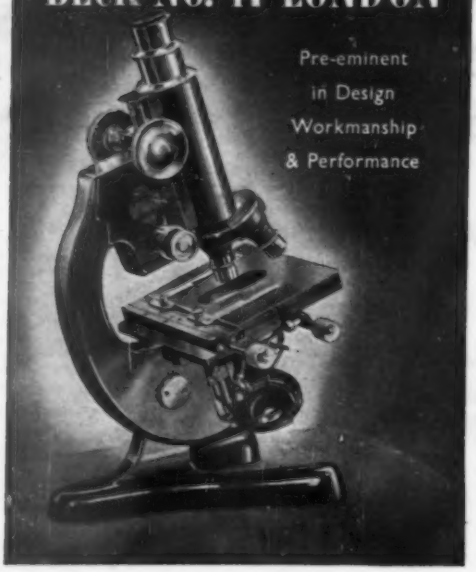

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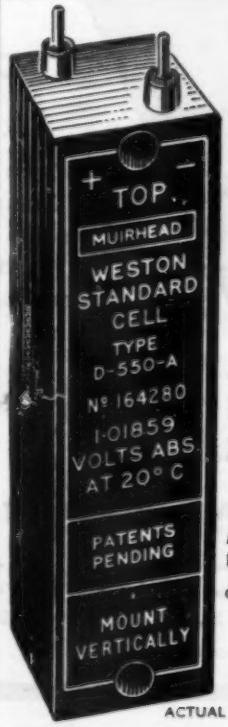


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Printed in Great Britain by Fisher, Knight & Co., Ltd., The Gainsborough Press, St. Albans, and published by Macmillan & Co., Limited, at St. Martin's Street, London, W.C.2, and The Macmillan Co., 60 Fifth Avenue, New York 11, N.Y., U.S.A.—Saturday, February 17, 1951.